

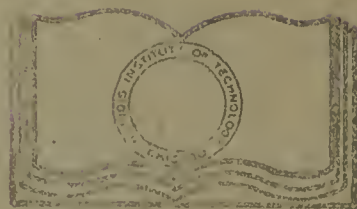
DESIGN AND COST
OF
HIGHWAY RECONSTRUCTION

BY
O. E. ANDREN
J. D. HARVEY
L. E. STARKEL

ARMOUR INSTITUTE OF TECHNOLOGY

1917

625.7
H 26

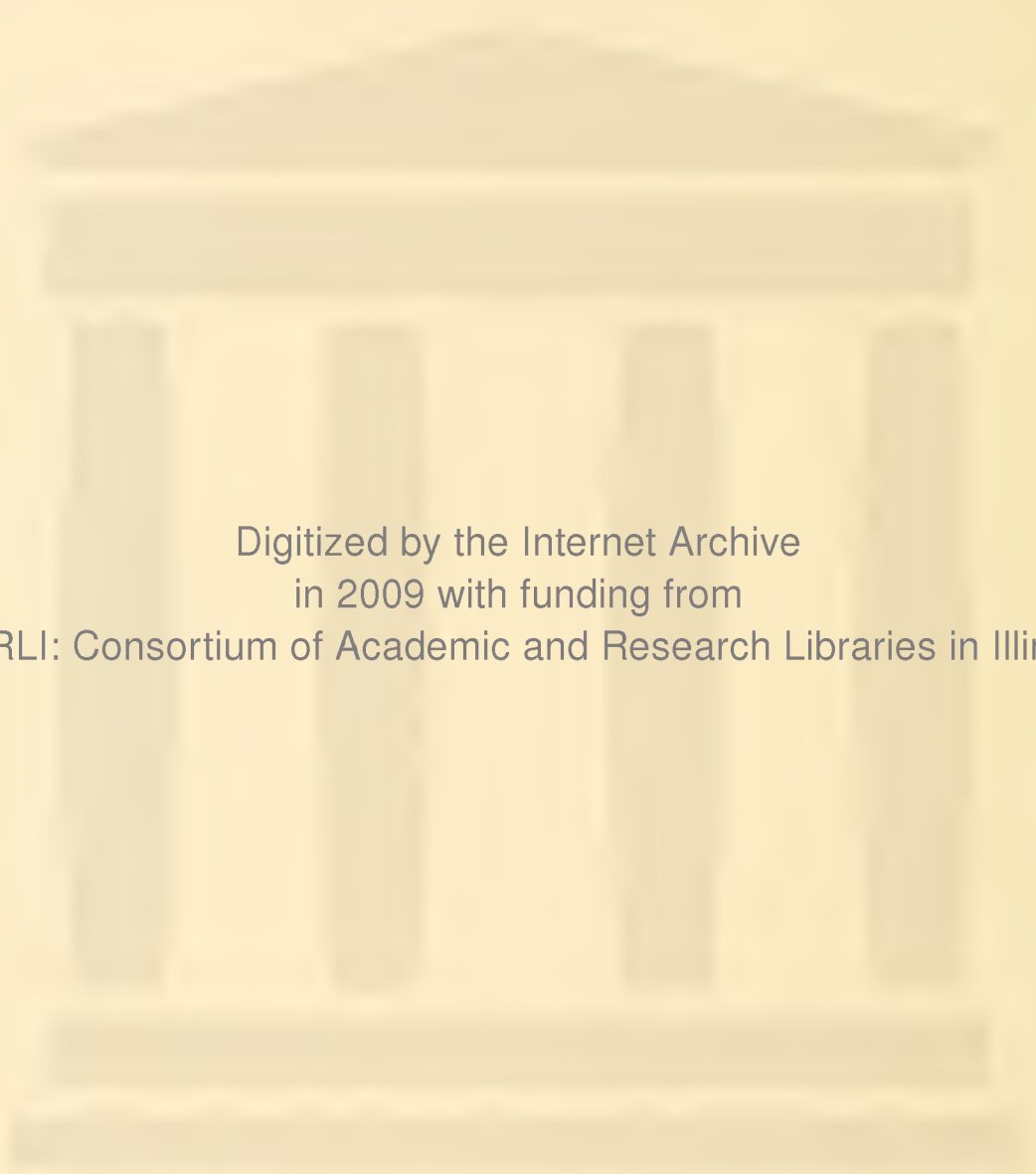


Hiram Institute
of Technology
UNIVERSITY LIBRARIES

AT 452

Harvey, J. D.

The design and cost of a
highway reconstruction



Digitized by the Internet Archive
in 2009 with funding from
CARLI: Consortium of Academic and Research Libraries in Illinois

THE DESIGN AND COST OF A HIGHWAY RECONSTRUCTION

A THESIS

PRESENTED BY

JAMES D. HARVEY, LEONARD E. STARKEL
OLOF E. ANDREN

TO THE

PRESIDENT AND FACULTY

OF

ARMOUR INSTITUTE OF TECHNOLOGY

FOR THE DEGREE OF

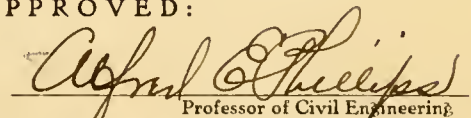
BACHELOR OF SCIENCE

IN

CIVIL ENGINEERING

MAY 31, 1917

APPROVED:


Professor of Civil Engineering


Dean of Engineering Studies


Dean of Cultural Studies

ILLINOIS INSTITUTE OF TECHNOLOGY
PAUL V. CALVIN LIBRARY
35 WEST 33RD STREET
CHICAGO, IL 60616

Methods and Costs of Reconstruction of a Highway

TABLE OF CONTENTS

Object	1
Discussion	2
Economic Advantages	5
Federal and State Aid	13
Methods of Procedure	16
Vertical Curve Computations	30
Costs	32
Summary of Estimate-	34
Earthwork Computation sheets	35

BLUEPRINTS

Two sheets Plan and Profile
One sheet Cross-Sections
Three Culverts
Abutments
Mass Diagram

Methods and Costs of Reconstruction of a Highway

OBJECT

The following thesis comprises a complete analysis of a highway reconstruction,,and the discussion of the conditions which render valuable such an analysis. The section of highway selected for the work lies in Rock County, Wisconsin, on the road between Edgerton and Cooksville. The community is a typically rural one and the almost impassable condition of the road during rainy season, requires the application of real highway methods.

THE HISTORY OF THE UNITED STATES OF AMERICA

CHAPTER I

The first discovery of the continent of America was made by Christopher Columbus in 1492. He sailed from Spain in search of a westward route to the Indies, and after a long and perilous voyage, he landed on the island of San Salvador in the West Indies. This discovery opened up a new world of trade and exploration for the Europeans. The following years saw the arrival of other explorers, including Vasco Nunez de Balboa, who discovered the Pacific Ocean, and Juan Ponce de Leon, who discovered Florida. The Spanish government established colonies in the Americas, and the English followed suit, founding the first permanent English colony in Jamestown, Virginia, in 1607. The American Revolution broke out in 1775, and the United States declared its independence from Britain in 1776. The new nation faced many challenges, including the War of 1812 and the Civil War, but it emerged as a powerful and independent country.

Methods and Costs of Reconstruction of a Highway

Historians say that Ancient Rome never could have been a great nation but for its splendid roads. We may draw the rapid conclusion from this statement that the prosperity and power of our nation will be accompanied, and in a measure caused, by the developement of our highway system. Railway and water routes will always be the medium of inter-city and inter-state transportation, and these have been developed to a high degree; but the cities and states so connected are insignificant in number compared with the villages and towns which are in some respects, the basic economic units. For these villages and towns, the highway will always be an important problem, and strange to say, our Nation as a whole has been more remiss in developing this important function than the ordinary person realizes. The subject of good roads now seems

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

...the ... of ...

Methods and Costs of Reconstruction of a Highway

to many to be a vexatious proposition requiring over-burdensome taxation and bother, but it has been proved conclusively that money properly invested in road improvements actually yields benefits, socially and economically, to a larger percentage than the ordinary business investment.

The succeeding analysis of a highway reconstruction concerns a rural road burdened with the usual problems and obstacles, and it might be well to point out the need and value of such work; and to give a resumé of Federal, State and County provisions and enactments bearing on it.

When the various ways in which good roads benefit a community are examined, a complex situation is found in which many actions and reactions take place. When good roads

Methods and Costs of Reconstruction of a Highway

reduce the cost of hauling, adjacent land becomes more valuable; There is a corresponding tendency for the population to increase, and in its turn, this tendency strengthens the demands for good roads; social conditions improve; and the life of the community is influenced in numerous ways. It is not always correct to say that good roads are the primary cause of increase in property valuation. It is, however, to conclude that good roads and an increased property valuation are inseparable.

Methods and Costs of Reconstruction of a Highway

There are certain direct financial advantages which follow the improvement of public roads in a community. These advantages are probably more apparent in the reduced cost of hauling. Certain dependent economic advantages also arise from such improvements, for example the increased value of farm lands. It should not be considered, however, in presenting the advantages of improved roads, that the direct cost of hauling and the increase in farm values are entirely separate and independent, for the values increase when the costs of hauling decrease.

Whatever methods are used to improve a road, the improvement for hauling purposes is due to three causes: the betterment of the road surface, the grade reduction and the shortening of the length. On such an improved road, the time required to haul a given quantity of

1870

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

...

Methods and Costs of Reconstruction of a Highway

material a given distance is reduced. The reduction may be due largely to increased speed of hauling, to increased load, or both. It is important to recognize that for transportation purposes, reduction of time is equivalent to a decrease to the distance to the market centers. It is very easy to see then, why the increase of farm values must follow improved roads, for the effect is to bring the farms, in a sense, closer to the towns. The fact, that on roads with improved surfaces, hauling becomes largely independent of the season of the year, or weather conditions, means very considerable reductions in hauling costs. It also means that many of the limitations of the number and kinds of farm operations are immediately removed.

In order to fix one's ideas on the reduction of hauling cost due to road improvement, the transportation of goods to the railroad and of farm produce to the market should

...and the

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

... ..

Methods and Costs of Reconstruction of a Highway

be considered. The present cost of this work in the United States is high, and is due in the main, to steep grades and yielding road surfaces. On any grade, in addition to the tractive forces due to surface conditions, the force of gravity must be overcome. The horse must raise his own weight and, because of the manner in which his strength is applied, it becomes less and less available as the grade increases. For example, if a 1200-pound horse, by exerting a force equal to one-tenth of his weight, can draw a load of about 2000 lbs. on a level earth road; with the same force exerted against his collar he can draw continuously only about 1000 lbs. on a 5 percent grade, and only 750 lbs. on a 10 percent grade. The worst grade on any road tends to limit the load that can pass over the entire road, even though for short pulls the horses' efforts may

Methods and Costs of Reconstruction of a Highway
be doubled.

While steep grades are detrimental on common earth roads, they are far more so on an improved road. If it is assumed that a 1200-pound horse by exerting a certain effort, can draw a load of 2000 lbs. on a level earth road, under the same conditions, this same horse can draw a 5000 lb. load continuously on a level macadam road, but on a 5 percent grade it can draw only 1600 lbs., while on a 10 percent grade the load would have been reduced to 950 pounds. It is because the tractive force on a macadam surface is so slight the the grade effect quickly exceeds that resistance.

It becomes immediately apparent, therefore, that, when a road is to be improved by surfacing it, the maximum grade allowed must be low in order to secure the full advantage of

Methods and Costs of Reconstruction of a Highway

The improvement. Moreover, steep grades are slippery and the maintainance charges are high, so the better the surface is made the more imperative it becomes to secure easy grades.

The cost of hauling farm produce to market is probably increased more by the bad conditions of road surfaces than by excessive grades. It is too frequently the case that at seasons when it is most desireable to use the roads the surfaces are soft and consequently the tractive resistances are excessive and wasteful. On a muddy road the amount of load which an ordinary horse can draw varies from nothing to a maximum of 600 lbs.; while on a well maintained gravel road, such as is used in the succeeding analysis, the amount would be about 3300 pounds. This means that the same horse could do about four times as much work on a good gravel surface than it could do on a muddy earth road.

Methods and Costs of Reconstruction of a Highway

Applying business methods of cost analysis to the farmers hauling problems, some enlightening figures are revealed. In 1906, the Department of Agriculture deduced an average cost per ton-mile of 23 cents, for average hauls of 9 miles, based upon replies received from a large number of rural correspondents.

A few individual instances of actual experiences will be cited. A certain farmer had to haul some material a distance of 23 miles. He found that with a two-horse team he could haul a load of 500 lbs. in three days with a ton-mile cost of \$1.56. Later this road was improved with a good gravel surface and the ton-mile cost was reduced to 26 cents. In another case, before improvement, farmers made a certain haul in a day, pulling 2500 lbs. per team. After the improvement of the road, the same teams made the hauls twice a day,

Methods and Costs of Reconstruction of a Highway

pulling 6000 pounds each. In another case, after some county road surfacing had been completed, farmers hauling wheat from their town to the nearest railroad center, found that the hauling cost had been reduced from 15 to 4 cents per bushel. The South is sadly behind in road improvement. With a hauling cost of \$40,000,000 per year for the cotton crop, an expenditure of \$2,000,000 for roads would yeild big dividend in the reduction of this enormous cost.

The problem of production is decreased simultaneously with the decrease of hauling expence. Where bad roads prevail the farmers are forced to mow their crops, not when the market is favorable, but when the roads are favorable. Oftentimes when the market is highest, the rural producer finds that he cannot get his produce to market, and when the roads become

Methods and Costs of Reconstruction of a Highway

passable, the market is so flooded that much of the crop is wasted. In a certain winter when potatoes rose to an exorbitant price, certain farmers with heavy drops were unable to haul to town, and much of their crop rotted.

It is because of the above considerations and others that the improvement of our highways is expected to stem the drift of population toward the cities and to increase the country's productions in proportion to its growth.

Methods and Costs of Reconstruction of a Highway

Federal and State Aid work is highly instrumental in the present road improvements. Federal Aid on a practical scale, dates from an enactment of Congress during its 1916 session, by which \$85,000,000 was appropriated to be distributed in 5 years among the several states on bases of area, population, and mileage of rural delivery and post-office station routes. State Aid work as practised by the State of Illinois (Illinois being fairly typical) provides for financial aid in the construction of permanent highways connecting centers of trade, to the extent of 50 percent of the cost. Besides this, all engineering and inspection work is provided for by the State. In addition to this the State takes over and maintains the highway thereafter, if the road is of brick, concrete or asphalt; and to pay for half of its maintenance if

THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO

Methods and Costs of Reconstruction of a Highway

the pavement is of gravel, or macadam.

Since the passage of the Good Road Acts, July 1913, Illinois has constructed 400 miles of highway under State supervision. All such work has been accomplished according to the State specifications, and the general routes have been determined by it. This ruling is necessary if permanent traffic routes are to be built, and its need is attested when it is considered that the State of New York in the expenditure of \$250,000,000 for roads, wasted a shameful percentage due to mistakes and hit-or-miss methods.

During the years 1916 to 1921 incl., the State of Illinois will receive \$3,300,000 from the Federal government provided, however, the State appropriates a like amount. As there is no doubt but what the State will supply

Letter to the Hon. the Secretary of the Navy

Washington, D.C., 18th March 1881

Sir,

I have the honor to acknowledge the receipt of your letter of the 11th inst.

and in reply to inform you that the same has been forwarded to the proper authorities.

I am, Sir, very respectfully, Sir, your obedient servant,

John D. Long, Secretary of the Navy

Enclosed for the Secretary of the Navy are two copies of a report

of the Committee on the Navy, dated 18th March 1881.

I am, Sir, very respectfully, Sir, your obedient servant,

John D. Long, Secretary of the Navy

I am, Sir, very respectfully, Sir, your obedient servant,

John D. Long, Secretary of the Navy

Very respectfully,
John D. Long

Enclosed for the Secretary of the Navy are two copies of a report

of the Committee on the Navy, dated 18th March 1881.

I am, Sir, very respectfully, Sir, your obedient servant,

John D. Long, Secretary of the Navy

I am, Sir, very respectfully, Sir, your obedient servant,

Methods and Costs of Reconstruction of a Highway

the required amount, the prospect for the near-future looks very bright. The growth of the highway may well be attested when it is considered that the amounts expended in 1916 in Illinois were four times those expended in 1904. That such investments of money are the key to progress is shown in the comparison of our own State with that of Arkansas and South Carolina, which have actually fallen behind in their mileage of good roads and as a consequence have fallen behind the other states in growth and population and prosperity.

There can be no real preparedness for war, for defence, or for peace, without real highways; and when every corner of our country is interconnected by comprehensive, permanent and well maintained systems, the effect will be apparent in prosperity and economic welfare.

THE UNIVERSITY OF CHICAGO

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

— THE UNIVERSITY OF CHICAGO, CHICAGO, ILL. 60637

Methods and Costs of Reconstruction of a Highway

The road taken as an example is on the direct route between Edgerton and Cooksville, Rock County, Wisconsin. Our section begins at the termination of the section already improved, and is about five miles out of Edgerton.

In Rock County gravel is in abundance, and consequently all of the improved roads are constructed of this material. The section of road improved, immediately ahead of our section, is a two-course gravel road nine feet wide with five-foot earth shoulders. After two years of service, this road has few ruts and nothing has been spent as yet on its maintenance.

Gravel for this road was obtained from a gravel pit located two miles from station 0 of our section. A royalty of \$.10

THE UNIVERSITY OF CHICAGO

PHYSICS DEPARTMENT

REPORT ON THE PROGRESS OF WORK

FOR THE YEAR 1900

BY

ALBERT A. MICHAELSON

AND

WILLIAM D. HANCOCK

CHICAGO, ILL., 1901

THE UNIVERSITY OF CHICAGO PRESS

PRINTED BY THE UNIVERSITY OF CHICAGO PRESS

CHICAGO, ILL., 1901

THE UNIVERSITY OF CHICAGO PRESS

PRINTED BY THE UNIVERSITY OF CHICAGO PRESS

CHICAGO, ILL., 1901

THE UNIVERSITY OF CHICAGO PRESS

PRINTED BY THE UNIVERSITY OF CHICAGO PRESS

CHICAGO, ILL., 1901

THE UNIVERSITY OF CHICAGO PRESS

PRINTED BY THE UNIVERSITY OF CHICAGO PRESS

CHICAGO, ILL., 1901

THE UNIVERSITY OF CHICAGO PRESS

PRINTED BY THE UNIVERSITY OF CHICAGO PRESS

CHICAGO, ILL., 1901

Methods and Costs of Reconstruction of a Highway

per cubic yard was paid to the owner of the property from which the gravel was extracted. A standard gravel grader, the product of the "Good Roads machinery Co.", is located at this pit. An endless-chain bucket-belt elevates the gravel to the screens and thence to the elevated hoppers. By this scheme the gravel may be dumped directly into the wagons for hauling to the job. The complete cost of gravel at the the bins is \$.25 per cubic yard. The gravel from this outfit is furnished by the County to the contractor at the above price, F.O.B. the plant. This outfit is available for use on the section of road considered by us, and the costs of the road metal are calculated from the above figures.

The survey of a road for the consideration of reconstruction consists of tran-

REPORT
OF THE
COMMISSIONER OF THE
LAND OFFICE

FOR THE YEAR 1887

The Commission has the honor to acknowledge the receipt of your report of the year 1886, and to express its appreciation of the care and attention which you have bestowed upon the discharge of your duties. The report is a valuable contribution to the knowledge of the land office, and its contents are of great interest to the public.

The report is divided into two parts, the first of which contains a general statement of the land office, and the second a detailed account of the work done during the year. The first part is a summary of the land office, and the second is a detailed account of the work done during the year. The report is a valuable contribution to the knowledge of the land office, and its contents are of great interest to the public.

Very respectfully,
Your obedient servant,
Commissioner of the Land Office

1887

Methods and Costs of Reconstruction of a Highway sit line, profile and cross-sections. Stakes are set at every hundred feet, or at intermediate points when necessary; and the distances of their location from the transit line are noted. They are usually placed at the fence line. Elevation of the top of each stake is noted and used for future reference.

Our stretch of road had been surveyed the previous autumn and the stakes were in place for the most part. In running the transit line the approximate center between fences was taken at each perceptible change in direction of the road; and straight lines between these successive points were considered as center-lines of the proposed improvement. The azimuth of each new direction was noted, in order to determine the different bearings of the road, and the interior angles at the intersection points. Distances to stakes, fences, etc., were noted

Methods and Costs of Reconstruction of a Highway

and the pluses of the various existing culverts, private entrances, houses, barns, etc., were taken in relation to their position with the existing stakes. The stations were not chained, due to the fact that these stakes from the previous survey were in place.

The profile was run down the center line of the road, picking up from an assumed bench mark located on the culvert at station 2 plus 50. The elevation of this B.M. was taken as 100.00. Elevations were taken at every hundred feet and at intermediate points when necessary. The elevation of the inlets and outlets of the existing culverts were noted. Center-line elevations of private entrances were taken in order not to place the new grade line in such a position as to ultimately be objectionable to the property owner.

Methods and Costs of Reconstruction of a Highway

Cross-sections were taken at every station and at private entrances. No bench marks, or turning points were used in taking the sections, as only the difference in elevations of the prominent points of the several sections were needed. The first reading taken in sectioning was at the center of the road; then the readings of the changes in topography to the right and thence to the left of the center line were noted. Such sections were generally taken as far out as the fence lines on each side and farther out where deemed advisable.

The method of running each phase of the survey separately, was chosen by us to be the most efficient method for a party of three men to employ. The length of road included in this survey extends one hundred and four stations. In this stretch of road, practically every road problem known, was encountered.

Methods and Costs of Reconstruction of a Highway

Between stations 30 and 42 plus 50, the bottoms of the Yahara River were crossed. The river overflows these bottoms and the road to a considerable depth every Spring. It is impassable, even to horse back, during these flood periods. The high water elevation, relative to the piers of the bridge was obtained from the County Superintendant of Rock County. To allow of continuous traffic during these freshets, we propose that the section of road that is innundated be provede with a specially designed concrete spillway, or ford. To the wets end of the bottoms, a steel bridge of a hundred foot span, which crosses the channel of the river, is in place. This bridge, we propose to raise in order that it will clear the flood level during the freshet overflow. At the east end of the bottoms, the existing grade is somewhat over twelve percent, while

Methods and Costs of Reconstruction of a Highway

the upgrade from the bridge floor west is about nine percent.

The material encountered, for the most part, is heavy soil, or muck. This material becomes practically bottomless when the frost leaves the ground in the Spring of the year, as we discovered by experience.

The plans included herein, were plotted from the survey notes. The scale of the transit line is 1 in. equals 80 ft.; and that of the profile is 1 in. equals 80 ft., horizontally, and 1 in. equals 8 ft., vertically. The ratio of 1 to 10 of the scales of the profile was so taken as to make the variations of the ground visible. The scales used on the cross-sections are both 1 in. equals 8 ft.

A standard road template is used to plot the new road section on the section of the

Methods and Costs of Reconstruction of a Highway

ground line. This template includes the finished earth portion, or sub-grade of the proposed improvement. Of course, the ditches and the trenches wherein the road metal is placed, are shown on this template. As the grade line on the profile is that of the center-line of the finished improved road, a projection of the template material extends to the level of that finished surface. By means of such, the correct position of the new section is located very easily on the ground section through the elevation taken from the grade line. That is, it is unnecessary to take any separate measurements in plotting. The material of the template was of heavy bristol board.

The typical cross-section of this road consists of a two-course gravel roadway, having a total thickness of seven inches and a width of eight feet. There are six foot

Methods and Costs of Reconstruction of a Highway

earth shoulders on each side of the gravel pavement. The crown of the road section is sloped from the center to the edge of the earth shoulders with a gradient of 1 in 12. Generally the depth of the ditches below the center of the proposed improvement is twenty-two inches; and the slope of the side wall is 3 to 1. The fill section differs from this, inasmuch as the slope from the edge of the earth shoulders is 1 to 1. At the peaks of the grade lines the ditches are omitted for about three, or four hundred feet on each side of the point of intersection. Refer to section #A1 for fill, and #A2 for cut sections. All demensions are included therein. These are to be found on sheet No. 1 of the plan and profile.

For the special spillway section, a concrete roadway, eighteen feet wide, with rip-rap pavement on each side is proposed.

Methods and Costs of Reconstruction of a Highway

The concrete is to be laid in a single course, six inches in depth, with a crown having a slope of $1/2$ in 12 for the middle half of the pavement, and that of 1 in 12 for the two outside quarters of the section. The rip-rap pavement has a slope of 1 in 4 and is to be extended about six feet on each side of the concrete. The under drainage is taken care of by 4" drain tiles running longitudinally on both sides of the center, and at a distance of eight feet from it. This tiling has a gradient of 1%, and is so arranged as to have the low points midway between stations. The drainage of the longitudinal tile is by means of cross-tiles placed at each station. The tiling to the left side of the road has an elevation of 3" less than that to the right of the road, in order to provide a gradient for the cross-tile. The average depth of the tile is about two feet below the center

Methods and Costs of Reconstruction of a Highway
of the finished surface of the concrete road.

Preliminary to the determination of the grade line, the template was placed on the road section in such a manner, so that the cut would balance the fill for that section, and the resultant of the finished surface was then noted. These elevations were plotted on the profile and the grade line established by closely approximating these points. However, the elevations of some stations are predetermined by private entrances, culvert clearances, etc.; and the grade of the road had to be kept to 8%, or thereabouts, which caused excessive cuts in places. The advance upgrade is known as plus and the downgrade as minus. Vertical curves were used at the intersection of the profile lines and were calculated from the following formula:

$$D = \frac{(X + Y) \times T}{8}$$

Nomenclature

Methods and Costs of Reconstruction of a Highway

D is the offset from the point of intersection of the two grade lines; known as P.I.

X is the approach grade; Y the retreat grade. In the formula $X+Y$ means the algebraic sum of the two components.

T is the total length of stations covered by the curve and is expressed in terms of stations. These tangents, $(1/2 T)$ were assumed, the total amount of earthwork desired governing their length.

The offset to any point other than the P.I. was calculated by the following formula:

$$d' = D \frac{T^2}{Z^2}$$

Nomenclature:

Z is the distance measured horizontally and expressed in terms of stations, of the point of curvature, or point of tangency as the case might be, to the desired point.

Methods and Costs of Reconstruction of a Highway

Generally, the tangents assumed are either 50, or 100 ft.

The offsets at the intersection of the transit lines were calculated from the formula:

$$E = T \tan. 1/4 i.$$

T is the length of the tangent in feet and i the deflection angle at that point. Other points on these curves were calculated from the same formula that was used for vertical curves.

The earthwork was balanced within zones of 1000 feet in length so as to eliminate the possibilities of overhaul. An excess of 15% of the cut over the fill was necessary in order to provide for shrinkage. Free haul is universally considered as 700 feet; and it was used as such in our calculations. Indefinite overhaul was calculated by the mass-diagram method. The cross-sections were plotted by means of the template and the areas, cut and fill, measured by

Methods and Costs of Reconstruction of a Highway

the planimeter. These areas are known as end areas. The sums of the successive end areas were established, which are in direct proportion to the final earthwork, or yardage. The balancing at the required places and the percentages excess were calculated from the end areas. Final earthwork was obtained by extension from standard tables. The results of all this work may be found on the earthwork computation sheets, herein.

1. The first part of the report deals with the general situation of the country and the progress of the work during the year. It is divided into two main sections: the first section deals with the general situation of the country and the progress of the work during the year, and the second section deals with the results of the work during the year.

2. The second part of the report deals with the results of the work during the year. It is divided into two main sections: the first section deals with the results of the work during the year, and the second section deals with the results of the work during the year.

3. The third part of the report deals with the results of the work during the year. It is divided into two main sections: the first section deals with the results of the work during the year, and the second section deals with the results of the work during the year.

4. The fourth part of the report deals with the results of the work during the year. It is divided into two main sections: the first section deals with the results of the work during the year, and the second section deals with the results of the work during the year.

5. The fifth part of the report deals with the results of the work during the year. It is divided into two main sections: the first section deals with the results of the work during the year, and the second section deals with the results of the work during the year.

Methods and Costs of Reconstruction of a Highway

Computation of vertical curve offsets.

Sta.	Tan(ft)	Solution of D, or d'.
2+50	50	$(-.54-.60) 1/8 = 1.14/8 = .14$
6	50	$(.54-3.00) 1/8 = 2.46/8 = .31$
9	100	$(3.00-5.35) 2/8 = 2.35/4 = .54$
11	100	$(5.35+.20) 2/8 = 5.15/4 = 1.29$
17	100	$(.20 1.15) 2/8 = 1.35/4 = .34$
19	100	$(1.15-5.00) 1/8 = 3.85/8 = .48$
21	50	$(5.00-8.00) 1/8 = 3.00/8 = .37$
27+50	50	$(8.00-4.00) 1/8 = 4.00/8 = .50$
30	50	$(4.00+1.50) 1/8 = 2.50/8 = .31$
32	100	$(1.50-0.00) 2/8 = 1.50/4 = .40$
40+50	50	$(5.00-0.00) 1/8 = 5.00/8 = .62$
42+70	20	$(0.00 8.70) \times .05 = .43$
44	50	$(8.70-5.00) 1/8 = 3.70/8 = .47$
51	100	$(5.00-.50) 2/8 = 4.50/4 = 1.12$
53	50	$(0.50 0.40) 1/8 = .90/8 = .11$
55	50	$(0.40-1.70) 1/8 = 1.30/8 = .16$
57	50	$(1.70 1.50) 1/8 = 3.20/8 = .40$

Methods and Costs of Reconstruction of a Highway

Sta.	Tan(ft)	Solution of D, or d'.
62	50	$(1.50+0.40) \ 1/8 = 1.90/8 = .24$
64	100	$(0.40-1.60) \ 2/8 = 1.20/4 = .30$
68	100	$(1.60+3.60) \ 2/8 = 5.20/4 = 1.30$
71	100	$(3.60-2.80) \ 2/8 = 0.80/4 = .20$
74	100	$(2.80-0.10) \ 2/8 = 2.70/4 = .67$
80	100	$(0.10-6.40) \ 2/8 = 6.50/4 = 1.62$
84	50	$(6.40-0.00) \ 1/8 = 6.40/8 = .80$
89	100	$(0.00+1.70) \ 2/8 = 1.70/4 = .42$
93	100	$(1.70-1.40) \ 2/8 = 0.30/4 = .07$
95	50	$(1.40+2.40) \ 1/8 = 3.80/8 = .47$
98	200	$(2.40-0.10) \ 4/8 = 2.30/2 = 1.15$
97	100	$d' = 1.15 \ (1/2)^2 = 0.29$
99	100	$d' = 1.15 \ (1/2)^2 = 0.29$

THE JOURNAL OF THE ROYAL ANTHROPOLOGICAL INSTITUTE

No.	Vol.	Part	Date	Price
1	1	1	1871	1s.
2	1	2	1871	1s.
3	1	3	1871	1s.
4	1	4	1871	1s.
5	1	5	1871	1s.
6	1	6	1871	1s.
7	1	7	1871	1s.
8	1	8	1871	1s.
9	1	9	1871	1s.
10	1	10	1871	1s.
11	1	11	1871	1s.
12	1	12	1871	1s.
13	1	13	1871	1s.
14	1	14	1871	1s.
15	1	15	1871	1s.
16	1	16	1871	1s.
17	1	17	1871	1s.
18	1	18	1871	1s.
19	1	19	1871	1s.
20	1	20	1871	1s.
21	1	21	1871	1s.
22	1	22	1871	1s.
23	1	23	1871	1s.
24	1	24	1871	1s.
25	1	25	1871	1s.
26	1	26	1871	1s.
27	1	27	1871	1s.
28	1	28	1871	1s.
29	1	29	1871	1s.
30	1	30	1871	1s.
31	1	31	1871	1s.
32	1	32	1871	1s.
33	1	33	1871	1s.
34	1	34	1871	1s.
35	1	35	1871	1s.
36	1	36	1871	1s.
37	1	37	1871	1s.
38	1	38	1871	1s.
39	1	39	1871	1s.
40	1	40	1871	1s.
41	1	41	1871	1s.
42	1	42	1871	1s.
43	1	43	1871	1s.
44	1	44	1871	1s.
45	1	45	1871	1s.
46	1	46	1871	1s.
47	1	47	1871	1s.
48	1	48	1871	1s.
49	1	49	1871	1s.
50	1	50	1871	1s.
51	1	51	1871	1s.
52	1	52	1871	1s.
53	1	53	1871	1s.
54	1	54	1871	1s.
55	1	55	1871	1s.
56	1	56	1871	1s.
57	1	57	1871	1s.
58	1	58	1871	1s.
59	1	59	1871	1s.
60	1	60	1871	1s.
61	1	61	1871	1s.
62	1	62	1871	1s.
63	1	63	1871	1s.
64	1	64	1871	1s.
65	1	65	1871	1s.
66	1	66	1871	1s.
67	1	67	1871	1s.
68	1	68	1871	1s.
69	1	69	1871	1s.
70	1	70	1871	1s.
71	1	71	1871	1s.
72	1	72	1871	1s.
73	1	73	1871	1s.
74	1	74	1871	1s.
75	1	75	1871	1s.
76	1	76	1871	1s.
77	1	77	1871	1s.
78	1	78	1871	1s.
79	1	79	1871	1s.
80	1	80	1871	1s.
81	1	81	1871	1s.
82	1	82	1871	1s.
83	1	83	1871	1s.
84	1	84	1871	1s.
85	1	85	1871	1s.
86	1	86	1871	1s.
87	1	87	1871	1s.
88	1	88	1871	1s.
89	1	89	1871	1s.
90	1	90	1871	1s.
91	1	91	1871	1s.
92	1	92	1871	1s.
93	1	93	1871	1s.
94	1	94	1871	1s.
95	1	95	1871	1s.
96	1	96	1871	1s.
97	1	97	1871	1s.
98	1	98	1871	1s.
99	1	99	1871	1s.
100	1	100	1871	1s.

Methods and Costs of Reconstruction of a Highway

COSTS

Grading-

6682.2 yds. at \$.65 = \$4343.43

Overhaul-

15600 yds. hauled 100 ft. at \$.03 = \$468.00

Material for road surface-

Cost per yard (ave. haul 3 mi.) = \$1.30

Quarrying, spreading, etc. = \$.35

Total cost per cu. yd. = \$1.65

No. of cu.yards per 100 ft. = 19.8

No of stations 91 so the total number of

cu. yds. of gravel used is 1801.8

Total cost of material is \$2972.97

Cost of rolling at \$100.00 per mile = \$200.00

Complete cost of pavement = \$3172.97

Earth Shoulders.

6 foot earth shoulders on each side of road.

Number of sq.yds. per station 133

Methods and Costs of Reconstruction of a Highway

Total for 91 stations = 12133 sq. yds.

Cost at \$.02 per sq. yd = \$242.66

Spillway-

Yardage per station (concrete) = 33.3

Total yardage for 11.5 stations = 383.3

Cost of concrete at \$1.40 = \$657.80

Rip-rap-470 yds. at \$.25 = \$117.50

Tiling 1900 feet at \$.038 = \$72.20

Total cost of spillway = \$847.50

Culverts-

Three culverts with a total of 41.1 cu. yds.

at a cost of \$8.00 per cu. yd. = \$328.80

Bridge Abutments-

174 cu. yds. of concrete per abutment.

Total cost (two abutments) at \$6.00 per cu. yd.

(including raising of bridge) = \$2064.00

All of the prices noted in our estimates were obtained from the County superintendent of Highways, Rock County, Wisconsin.

Methods and Costs of Reconstruction of a Highway

Summary of Estimate.

Grading	\$4343.43
Overhaul	468.00
Gravel Pavement	3172.97
Earth Shoulders	242.66
Culverts	328.80
Spillway	847.50
Abutment	2064.00
Engineering	<u>500.00</u>
Total Cost	\$12003.51

STA.	ELEV.	SECTION AREA		END AREA	
		CVT -	FILL +	CVT -	FILL +
0	105.0	4.5	5.1		
1	104.4	5.8	5.1	10.3	10.3
2 P.C.	103.8	10.3	2.6	16.1	7.7
P.I.	(103.64)	-	-	-	-
2+50	103.5			17.3	7.7
3 P.T.	103.75	7.0	5.1	10.8	15.8
4	104.30	3.8	10.3	10.2	12.1
5 P.C.	104.85	6.4	2.6	10.2	4.2
6 P.I.	(105.71)	3.8	1.9	9.6	1.7
	105.41			3.3	2.0
7 P.T.	108.40	5.8	16.0	8.9	21.8
8 P.C.	111.40	6.4	12.8	21.8	14.2
9 P.I.	(114.94)	15.4	1.8	21.8	3.3
	114.40			15.9	11.1
10 P.C.	119.75	6.4	1.2	9.5	2.0
11 P.I.	(123.81)	9.5	10.2	9.0	2.0
	125.10			20.5	6.0
12	125.3	0	19.2	19.3	11.1
13	125.5	9.0	1.2	20.6	12.1
14	125.7	11.5	5.1	23.1	7.7
15	125.9	7.8	6.4	21.8	3.3
16 P.C.	126.10	12.8	6.4	24.3	12.1
17 P.I.	(125.96)	10.3	1.2	29.4	25.1
	126.30			37.1	15.1
18 P.T.	125.15	11.5	2.6	167.5	
19 P.I.	(123.52)	12.8	10.3	409.0	
	124.0			462.0	
20	119.0	16.6	15.4	105.0	2.0
21 P.I.	(113.63)	20.5	0	0	6.0
	114.0			0	5.0
22	106.0	147.0	0		
23	9.80	262.0	0		
24	(88.81)	140.0	0		
	88.80				
25 P.I.	82.0	0	20.8		
26	74.0	0	39.2		



STA.	ELEV.	SECTION AREA		END AREA		YARDAGE		REMARKS -
		CVT -	FILL +	CVT -	FILL +	CVT -	FILL +	
0	105.0	4.5	5.1					
1	104.4	5.8	5.1	10.3	10.2	19.1	18.9	
2 P.C.	103.8	10.3	2.6	16.1	7.7	29.8	14.3	
P.I.	(103.64)	-	-	-	-	-	-	
2+50	103.5	-	-	17.3	7.7	32.0	14.3	
3 P.T.	103.75	7.0	5.1	10.8	15.4	20.0	28.5	
4	104.30	3.8	10.3	10.2	12.9	18.9	23.9	
5 P.C.	104.85	6.4	2.6	10.2	4.5	18.9	8.3	
6 P.I.	(105.71)	3.8	1.9	9.6	17.9	17.8	33.1	15%
	105.41			3.3	28.3	6.1	53.3	
7 P.T.	108.40	5.8	16.0	8.9	15.2	24.1	29.5	
8 P.C.	111.40	6.4	12.8	21.8	14.6	40.4	27.0	
9 P.I.	(114.94)	15.4	1.8	21.8	3.0	40.4	5.6	
	114.40			15.9	11.4	29.4	21.1	
10 P.C.	119.75	6.4	1.2	9.5	28.7	17.6	53.1	
11 P.I.	(123.81)	9.5	10.2	9.0	20.4	16.7	37.8	
	125.10			20.5	6.3	38.0	11.7	
12	125.3	0	19.2	19.3	11.5	35.7	21.3	
13	125.5	9.0	1.2	20.6	12.8	38.1	23.7	
14	125.7	11.5	5.1	23.1	7.6	42.8	14.1	17%
15	125.9	7.8	6.4	21.8	3.8	40.4	7.0	
16 P.C.	126.10	12.8	6.4	24.3	12.9	45.0	23.9	
17 P.I.	(125.96)	10.3	1.2	29.4	25.7	54.4	47.6	
	126.30			37.1	15.4	68.7	28.5	
18 P.T.	125.15	11.5	2.6	167.5	0	310.2	0	
19 P.I.	(123.52)	12.8	10.3	409.0	0	757.4	0	
	124.0			462.0	0	856.0	0	
20	119.0	16.6	15.4	105.0	2.0	194.5	3.7	
21 P.I.	(113.63)	20.5	0	0	60.0	0	111.1	
	114.0			0	54.0	0	100.0	
22	106.0	147.0	0					
23	98.0	262.0	0					
24	(88.81)	140.0	0					
	88.80							
25 P.L.	82.0	0	20.8					
26	74.0	0	39.2					

STA.	ELEV.	SECTION AREA		END AREA	
		CVT -	FILL +	CVT -	FILL +
27 P.I.	66.0	0	14.8		
28 ^{0.00%}	(62.5) 60.0	32.0	0	32.0	1
29 ^{4.00%}	56.0	3.5	14.4	35.5	1
30 P.I.	(52.31) 52.0	07.0	1.0	10.5	1
31 ^{1.50%}	50.5	0	0	7.0	1
32 P.I.	(49.4) 49.0	0	14.4	0	1
33 ^{0.00%}	49.0	0	6.4	0	2
34 ^{CON. 5.00%}	49.0	12.5	0.8	12.5	
35	49.0	0	24.0	12.5	2
36	49.0	0	58.4	0	0
37	49.0	0	46.0	0	10
38	49.0	0	58.0	0	10
39	49.0	0	48.0	0	10
40	49.0	0	57.0	0	10
P.I.	(49.62)	—	—	—	
40+50	49.0	—	—	0	10
41 ^{1.50%}	51.5	0	108.0	0	10
P.I.	54.0	0	136.0	0	10
41+50	54.0	0	136.0	0	
42	—	—	—	—	
42+50	54.0	0	70.5	—	
P.T.	(54.43)	—	—	0	
42+70	54.0	—	—	—	
43 ^{0.07%}	56.6	0	41.0	—	
44 ^{1.07%}	(64.83) 65.3	3.0	0	3.0	4
45	70.3	5.1	5.7	35.1	
46 ^{1.50%}	75.3	4.0	24.0	9.1	2
47	80.3	7.7	25.5	11.7	4
48	85.3	4.5	12.0	12.2	
49	90.3	61.0	0	65.5	1
50 P.C.	95.3	2.6	0	87.0	
				29.8	1

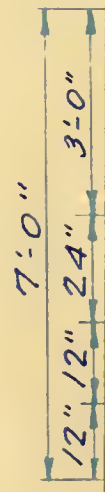
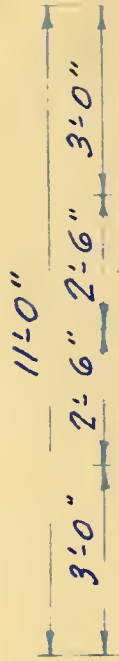
STA.	ELEV.	SECTION AREA		END AREA		YARDAGE		REMARKS
		CVT -	FILL +	CVT -	FILL +	CVT -	FILL +	
27 _{PI}	66.0	0	14.8					
28 _{PI}	(62.5) 60.0	32.0	0	32.0	14.8	59.3	27.4	
29 _{PI}	56.0	3.5	14.4	35.5	14.4	65.7	26.7	
30 _{PI}	(52.31) 52.0	07.0	1.0	10.5	14.4	19.4	26.7	
31 _{PI}	50.5	0	0	7.0	18.0	13.0	33.3	
32 _{PI}	(49.4) 49.0	0	14.4	0	14.4	0	26.7	
33 _{PI}	49.0	0	6.4	0	20.8	0	38.5	
34 _{PI}	49.0	12.5	0.8	12.5	7.2	23.1	13.1	
35 _{PI}	49.0	0	24.0	12.5	24.8	23.1	45.9	
36 _{PI}	49.0	0	58.4	0	82.4	0	152.6	
37 _{PI}	49.0	0	46.0	0	104.4	0	193.3	
38 _{PI}	49.0	0	58.0	0	104.0	0	193.0	
39 _{PI}	49.0	0	48.0	0	106.0	0	196.3	
40 _{PI}	49.0	0	57.0	0	105.0	0	194.5	
P.T. 40+50	(49.62) 49.0	-	-	-	-	-	-	
41 _{PI}	51.5	0	108.0	0	16.50	0	305.6	
P.T. 41+50	54.0	0	136.0	0	122.0	0	226.0	
42 _{PI}	-	-	-	0	0	0	0	
42+50	54.0	0	70.5	-	-	-	-	CENTER OF BRIDGE
P.T. 42+70	(54.43) 54.0	-	-	0	55.8	0	103.3	
43 _{PI}	56.6	0	41.0	-	-	-	-	
44 _{PI}	(64.83) 65.3	30	0	3.0	41.0	55.6	75.9	
45 _{PI}	70.3	5.1	5.7	35.1	5.7	64.8	10.6	
46 _{PI}	75.3	4.0	24.0	9.1	29.7	16.9	55.6	
47 _{PI}	80.3	7.7	25.5	11.7	49.5	21.7	91.7	
48 _{PI}	85.3	4.5	12.0	12.2	37.5	22.6	69.5	
49 _{PI}	90.3	61.0	0	65.5	12.0	121.3	22.2	
50 _{PI}	95.3	2.6	0	87.0	0	161.1	0	
				29.8	11.5	55.2	21.3	23%

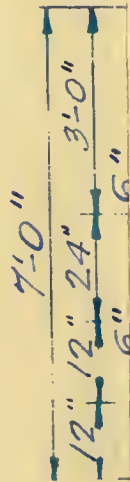
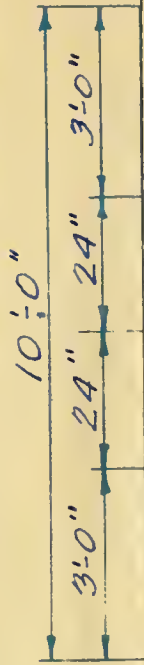
STA	ELEV.	SECTION AREA		END AREA	
		CUT -	FILL +	CUT -	FILL +
51 P.I.	(99.18) 100.3	3.8	11.5		
52	100.8	7.0	8.3	10.8	
53 P.I.	(101.19) 101.5	11.5	2.0	18.5	
54	100.9	6.4	7.0	17.9	
55 P.I.	(100.34) 100.5	5.8	16.0	12.2	
56	98.8	1.9	12.8	7.7	
57 P.I.	(97.51) 97.1	16.0	5.1	17.9	
58	98.6	2.6	11.0	18.6	
59	100.1	11.5	6.4	14.1	
60	101.6	25.6	0	37.1	
61	103.1	10.3	5.1	35.9	
62 P.I.	(104.36) 104.6	1.2	6.4	11.5	
63	104.2	3.2	7.7	4.4	
64 P.I.	(103.50) 103.8	16.0	1.2	19.2	
65	102.2	0.6	21.7	16.6	
66	100.6	3.2	12.8	3.8	
67	99.0	9.0	5.8	12.2	
68 P.I.	(98.7) 91.4	3.0	6.0	12.0	
69	101.0	5.8	22.4	8.8	
70	104.6	16.0	11.5	21.8	
71 P.I.	(108.0) 108.2	38.4	0	54.4	
72	111.0	—	—	—	
73 P.C.	113.8	71.8	24.3	93.2	
74	(115.93) 116.6	3.2	24.3	11.0	
75 P.T.	116.7	0	33.3	3.2	
76	116.8	0	32.0	0	
77	116.9	0	32.0	0	
78	117.0	22.4	0	22.4	
				111.9	

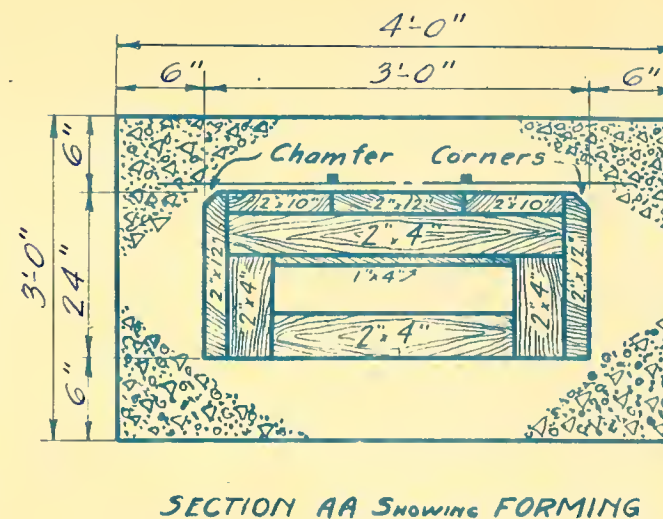
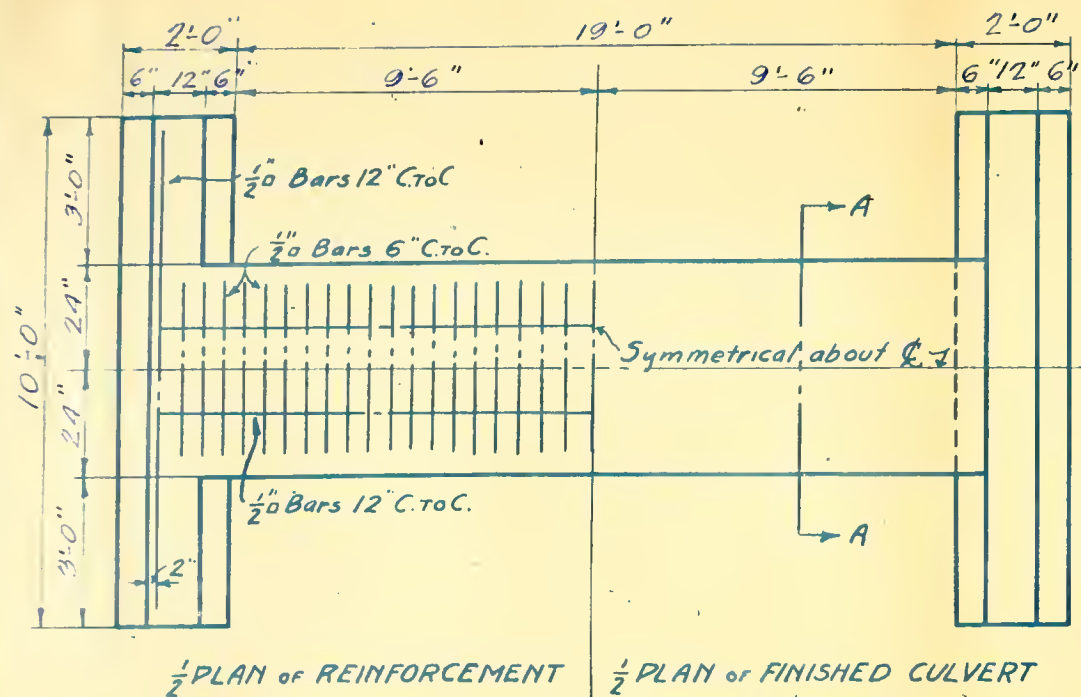
STA	ELEV.	SECTION AREA		END AREA		YARDAGE		REMARKS -
		CUT -	FILL +	CUT -	FILL +	CUT -	FILL +	
51 PI	(99.18) 100.3	3.8	11.5	10.8	5.0	20.0	9.3	15%
52	100.8	7.0	8.3	14.8	14.8	27.4	27.4	
53 PI	(101.19) 101.5	11.5	2.0	18.5	10.3	34.3	19.1	
54	100.9	6.4	7.0	17.9	9.0	33.1	16.7	
55 PI	(100.34) 100.5	5.8	16.0	12.2	23.0	22.6	42.6	
56	98.8	1.9	12.8	7.7	28.8	14.3	53.3	
57 PI	(97.51) 97.1	16.0	5.1	17.9	17.9	33.1	33.1	
58	98.6	2.6	11.0	18.6	16.1	34.4	29.8	
59	100.1	11.5	6.4	14.1	17.4	26.1	32.2	
60	101.6	25.6	0	37.1	6.4	68.7	13.7	
61	103.1	10.3	5.1	35.9	5.1	66.5	9.4	19%
62 PI	(104.36) 104.6	1.2	6.4	11.5	11.5	21.3	21.3	
63	104.2	3.2	7.7	4.4	14.1	8.1	26.1	
64 PI	(103.50) 103.8	16.0	1.2	19.2	8.9	35.8	16.5	
65	102.2	0.6	21.7	16.6	22.9	30.7	42.4	
66	100.6	3.2	12.8	3.8	34.5	7.0	63.9	
67	99.0	9.0	5.8	12.2	18.5	22.6	34.4	
68 PI	(98.7) 91.4	3.0	6.0	12.0	11.8	22.2	21.9	
69	101.0	5.8	22.4	8.8	28.4	16.3	52.6	
70	104.6	16.0	11.5	21.8	33.9	40.4	62.8	
71 PI	(108.0) 108.2	38.4	0	54.4	11.5	100.7	21.3	15%
72	111.0	-	-	-	-	-	-	
73 RC	113.8	71.8	243	93.2	3.0	172.6	56	
74	(115.93) 116.6	3.2	24.3	18.6	18.6	34.4	34.4	
75 PT	116.7	0	33.3	11.0	48.6	20.4	90.0	
76	116.8	0	32.0	3.2	57.6	5.9	106.6	
77	116.9	0	32.0	0	65.3	0	120.9	
78	117.0	22.4	0	0	64.0	0	118.5	
				22.4	32.0	4.5	59.3	
				111.9	0	207.2	0	

STA	ELEV.	SECTION AREA		END AREA	
		CUT -	FILL +	CUT -	FILL +
79	117.1	89.5	0		
80 P.I.	(115.50) 117.2	17.3	0	106.8	
81 6.40%	110.8	36.5	0	5.38	
82 6.40%	104.4	12.8	1.2	20.3	
83	98.0	0	48.6	29.0	
84 (92.4) 91.6		0	25.0	10.8	49
85	91.6	0	48.5	0	73
86 0.00%	91.6	9.0	57.5	0	7
87	91.6	16.0	16.0	9.0	10
88	91.6	6.4	20.5	25.0	7
89 (92.02) 91.6		22.4	3.2	22.4	30
90	93.3	24.3	0	28.8	2
91 11.79%	95.0	45.0	0	46.7	3
92	96.7	90.0	0	69.3	
93 P.I. (98.33) 98.4		25.0	0	135.0	
94 11.49%	99.8	9.0	3.2	115.0	
95 P.I. (100.73) 101.7		45.0	0	34.0	3
96 2.46%	98.8	5.8	13.0	54.0	3
97 R.I. (96.69) 96.4		5.1	28.8	50.8	13
98 P.I. (95.15) 94.0		0	24.4	10.9	41
99 P.I. (94.19) 93.0		0	28.8	51	6
100	93.8	8.3	7.7	0	6
101 10.10%	93.7	6.4	16.0	8.3	3
102	93.6	18.0	7.7	14.7	2
103	93.5	57.5	0	24.4	2
104	93.4	65.0	0	75.5	7
				122.5	

STA.	ELEV.	SECTION AREA		END AREA		YARDAGE		REMARKS -
		CVT -	FILL +	CVT -	FILL +	CVT -	FILL +	
79	117.1	89.5	0					
	(115.50)			106.8	0	192.8	0	
80 P.I.	117.2	17.3	0	5.38	0	99.6	0	
81	110.8	36.5	0	20.3		37.6		
	6.4%			29.0	1.2	53.7	2.2	15%
82	104.4	12.8	1.2	10.8	49.8	23.7	92.2	
83	98.0	0	48.6					
	(92.4)			0	73.6	0	136.2	
84	91.6	0	25.0					
				0	73.5	0	136.1	
85	91.6	0	48.5					
				9.0	106.0	16.7	196.3	
86	91.6	9.0	57.5					
	0.00%			25.0	73.5	46.3	136.1	
87	91.6	16.0	16.0					
				22.4	36.5	41.5	67.6	
88	91.6	6.4	20.5					
				28.8	23.7	53.3	43.9	
89	(92.02)	22.4	3.2					
P.I.	91.6			46.7	3.2	86.5	5.9	
90	93.3	24.3	0					
				69.3	0	128.3	0	
91	95.0	45.0	0					
	+1.7%			135.0	0	250.0	0	
92	96.7	90.0	0					
				115.0	0	213.0	0	16%
93 P.I.	(98.33)	25.0	0					
	98.4			34.0	3.2	63.0	5.9	18%
94	99.8	9.0	9.2					
	+1.5%			54.0	3.2	100.0	5.9	
95 P.I.	(100.73)	45.0	0					
	101.7			50.8	13.0	94.1	24.1	
96	98.8	5.8	13.0					
				10.9	41.8	20.2	77.4	
97 P.I.	(96.69)	5.1	28.8					
	96.4			51	67.2	9.3	124.4	
98 P.I.	(95.15)	0	24.4					
	94.0			0	67.2	0	124.4	
99 P.I.	(94.19)	0	28.8					
	93.0			8.3	36.5	15.4	67.6	
100	93.8	8.3	7.7					
				14.7	23.7	27.2	43.9	
101	93.7	6.4	16.0					
				24.4	23.7	45.2	43.9	
102	93.6	18.0	7.7					
				75.5	7.7	140.0	14.3	
103	93.5	57.5	0					
				122.5	0	226.9	0	32%
104	93.4	65.0	0					







BILL OF MATERIAL

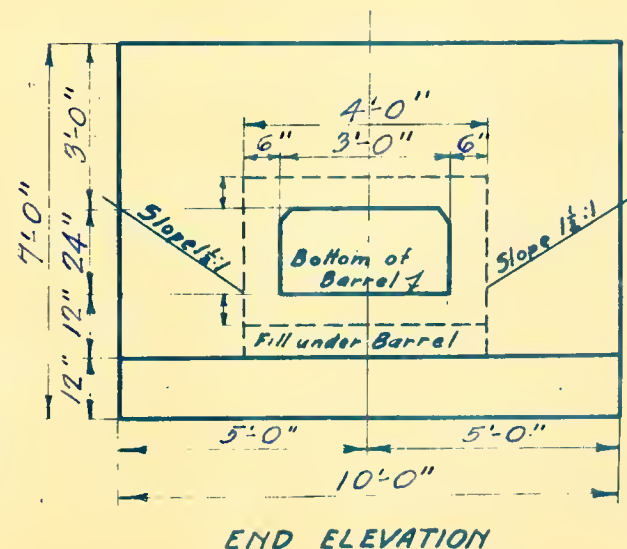
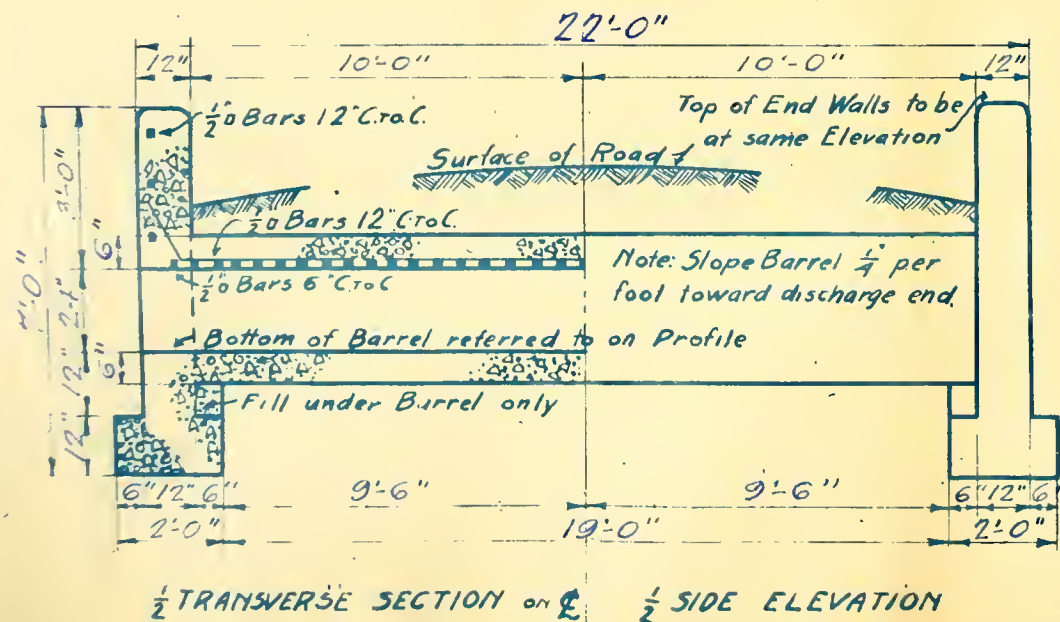
STEEL:

Bars 1/2" 12" C.to.C.	long-A
Bars 1/2" 6" C.to.C.	long-B
Bars 1/2" 12" C.to.C.	long-C
Total Steel =	Pounds.

CONCRETE 1:2:4 MIX.

Two End Walls Contain.... 8.0 Cu.Yds.
 Barrel 20'-0" long Contains. 5.6 Cu.Yds.
 Total Concrete..... 13.6 Cu.Yds.

CEMENT..... 13	13.0 Bbls.
SAND..... 39	3.9 Cu.Yds.
STONE..... 78	7.8 Cu.Yds.



CULVERT NO. **2**
 STATION NO. **69+60**

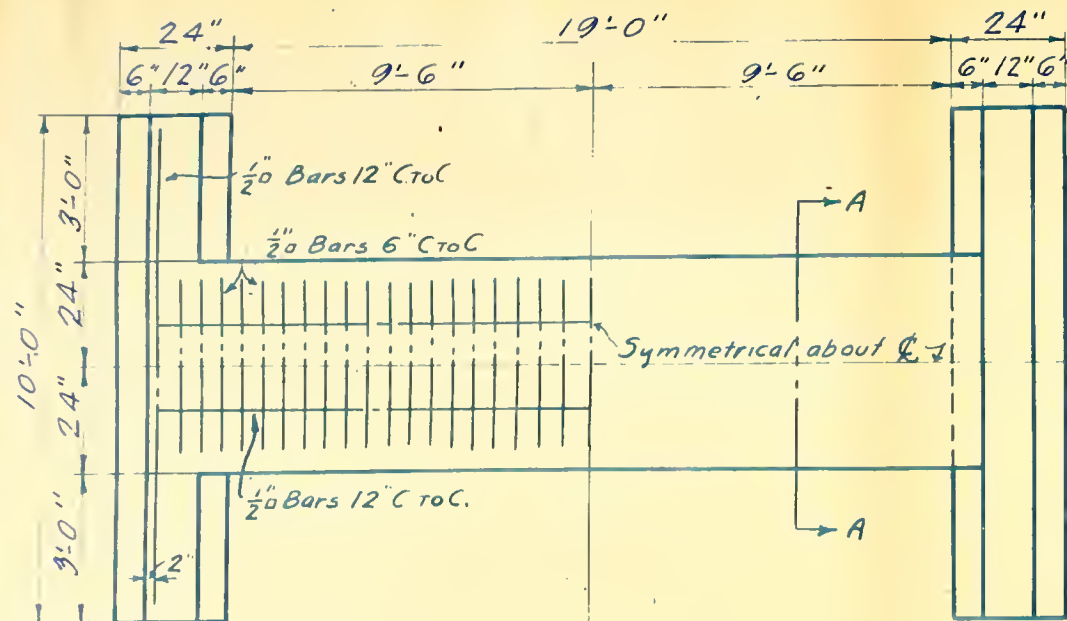
STANDARD 36"x24" REINFORCED CONCRETE CULVERT
 THESIS

CHICAGO, ILL. MAY 1917

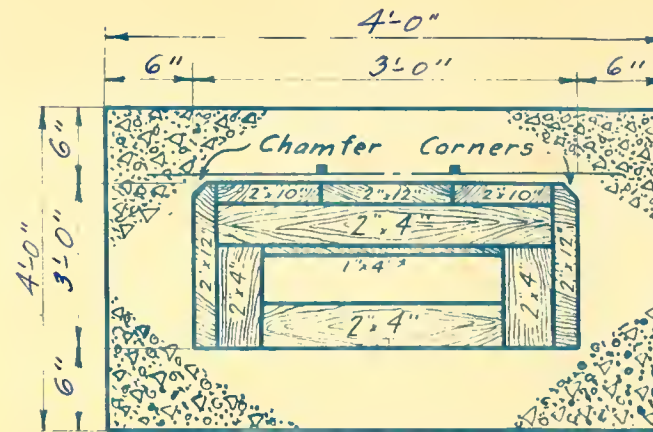
L.E. STARKEL, JAS. D. HARVEY, O.E. ANDRÉN

10'-0" 3'-0" 24" 24" 3'-0"

8'-0" 10" 10" 3'-0" 3'-0"



1/2 PLAN OF REINFORCEMENT 1/2 PLAN OF FINISHED CULVERT



SECTION AA SHOWING FORMING

BILL OF MATERIAL

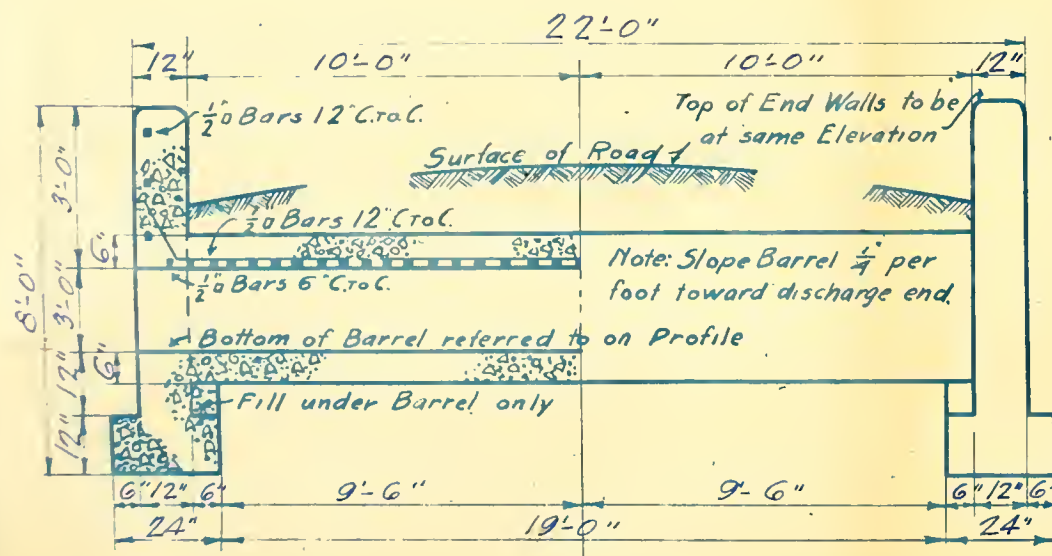
STEEL:

Bars 1/2" 12" C to C.	long-A
Bars 1/2" 6" C to C.	long-B
Bars 1/2" 12" C to C.	long-C
Total Steel =	Pounds.

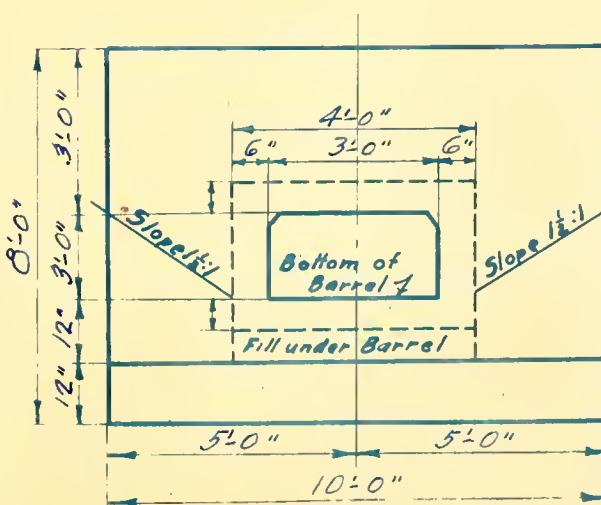
CONCRETE 1:2:4 MIX.

Two End Walls Contain.....	10.0 Cu.Yds.
Barrel 20'-0" long Contains.....	5.7 Cu.Yds.
Total Concrete.....	15.7 Cu.Yds.

CEMENT.....	15.0 Bbls.
SAND.....	4.5 Cu.Yds.
STONE.....	9.0 Cu.Yds.



1/2 TRANSVERSE SECTION ON C.L. 1/2 SIDE ELEVATION



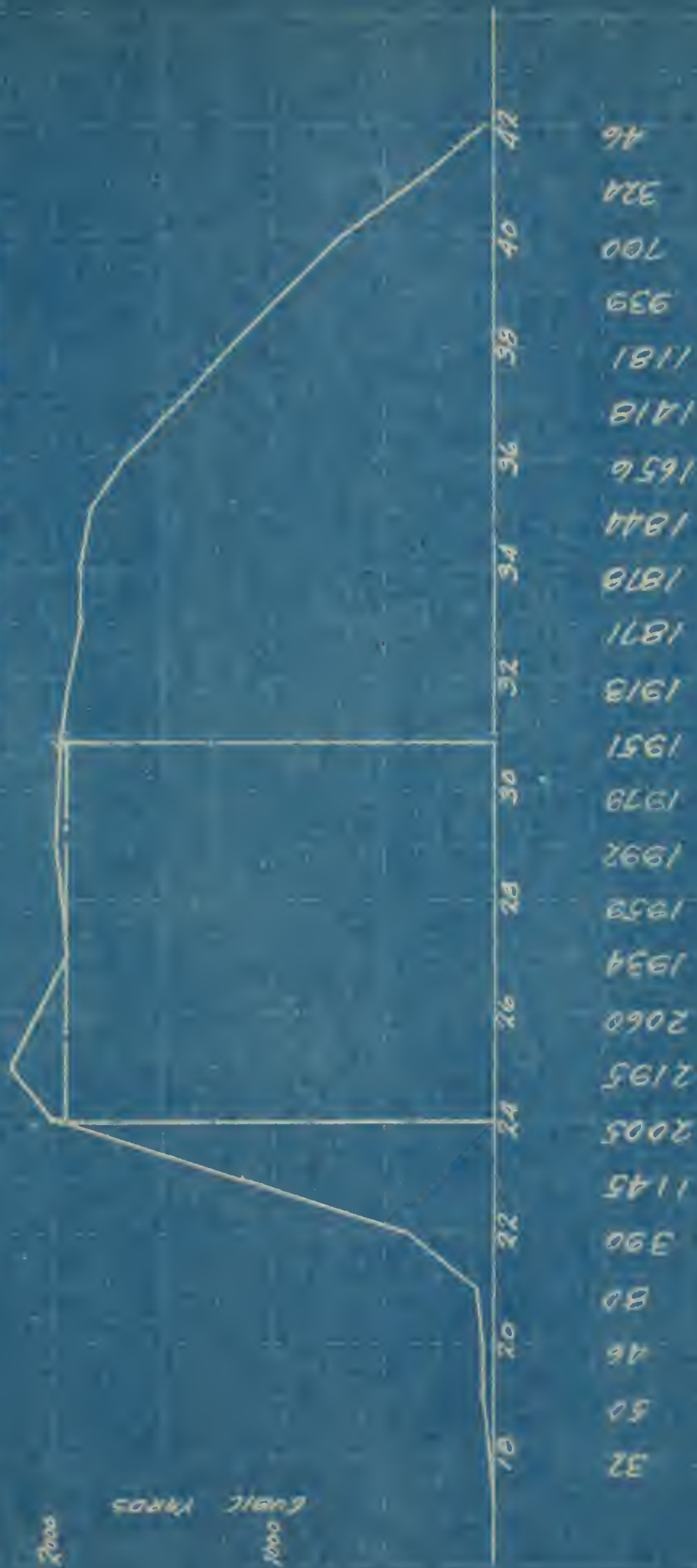
END ELEVATION

CULVERT NO. 3
STATION NO. 85+30

STANDARD 36" x 36" REINFORCED CONCRETE CULVERT
THESIS
CHICAGO, ILL. MAY 1917

L.E. STARKEL, JAS. D. HARVEY, O.E. ANDRÉN

- MASS DIAGRAM -
DETERMINATION OF OVERHAUL



OVERHAUL - 15,600 YDS. - 100 FT.

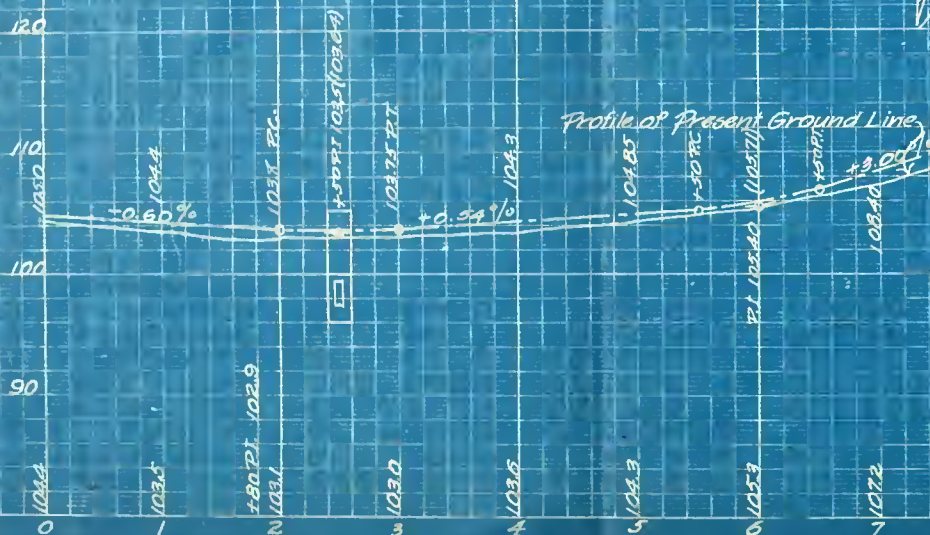
- THESIS -
OF ANDREW - L. E. STARNEL
J. D. HARVEY



PLAN AND PROFILE
SHEET NO. 1

Sta. 0 begins at Sta. 104 of
section already improved

Concrete Culvert in place
Sta. 2 +50 - 48" x 24" box
Elev. Inlet - 97.5'
Elev. Discharge - 97.0'
Elev. Road - 103.0'
B.M. N.E. Corner Culvert
Elev. assumed - 100.00'



METHODS AND COSTS OF RECONSTRUCTION OF A HIGHWAY.

- A THESIS -
PRESENTED BY

OLOF F. ANDREÉN - JAMES D. HARVEY - LEONARD F. STARKEL

TO THE
CIVIL ENGINEERING DEPARTMENT
OF
ARMOUR INSTITUTE OF TECHNOLOGY -

MAY 31, 1917

+75 Priv. Ent.
+80 Priv. Ent.

P.T. 125.10

P.T. 125.3

P.T. 125.7

P.T. 125.9

P.T. 126.1 EC

P.T. 125.15 P.T.

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

P.T. 125.0

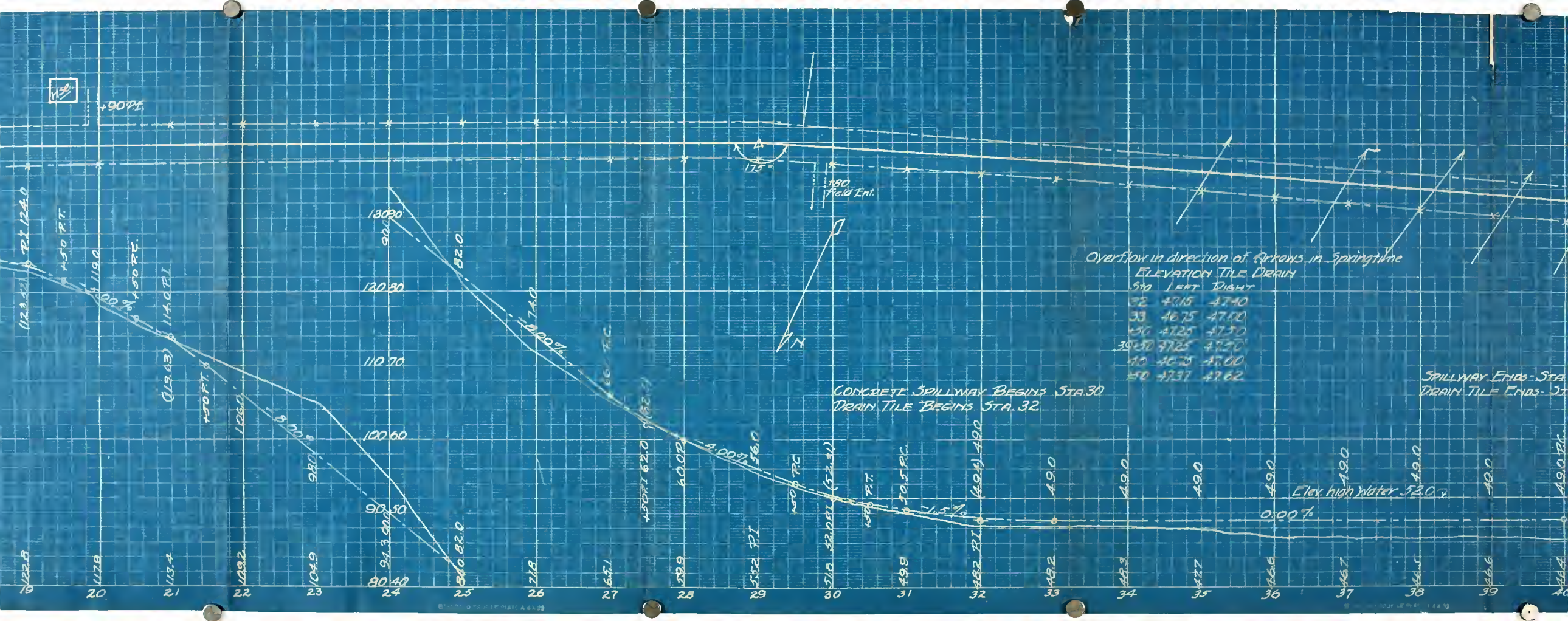
P.T. 125.0

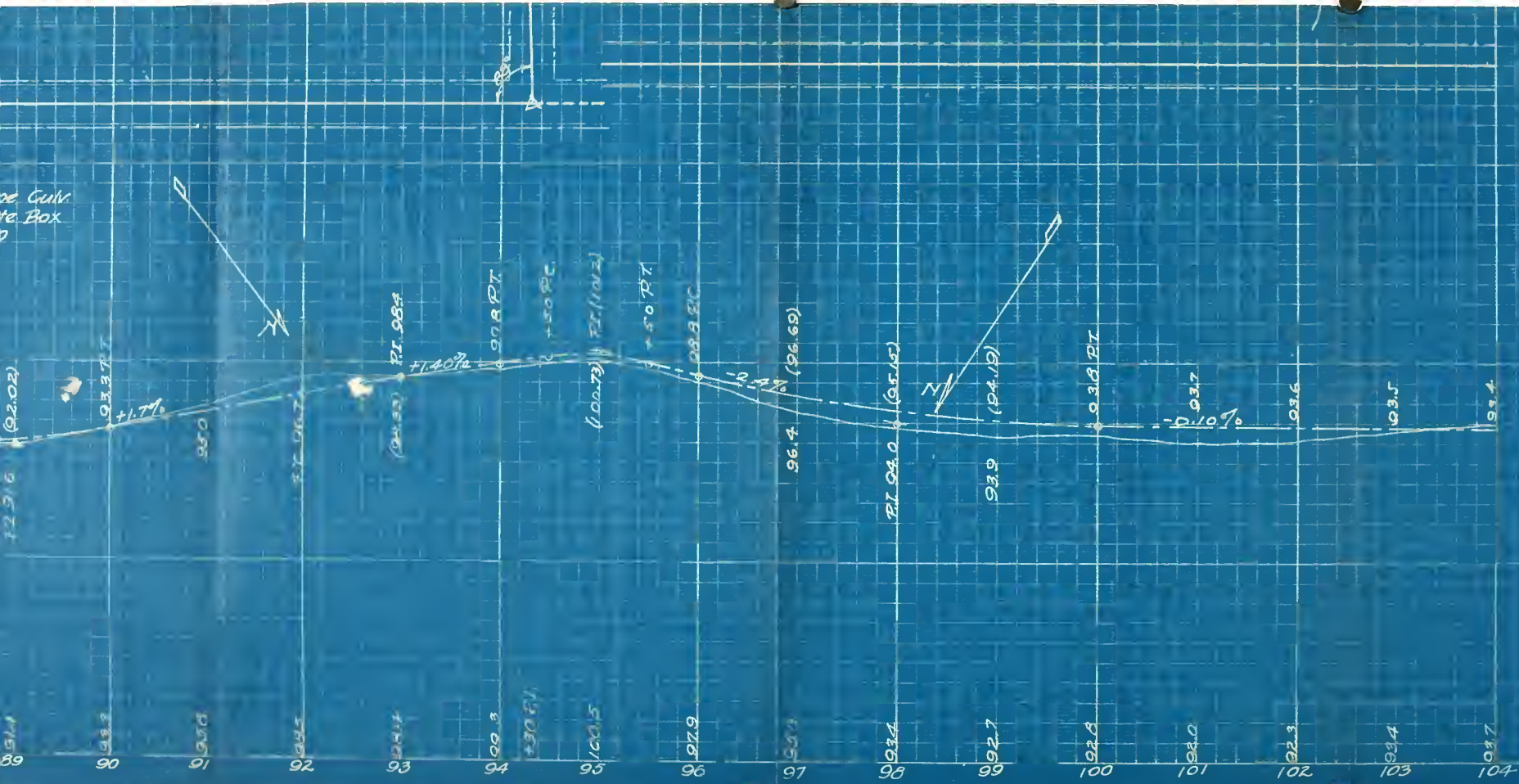
P.T. 125.0

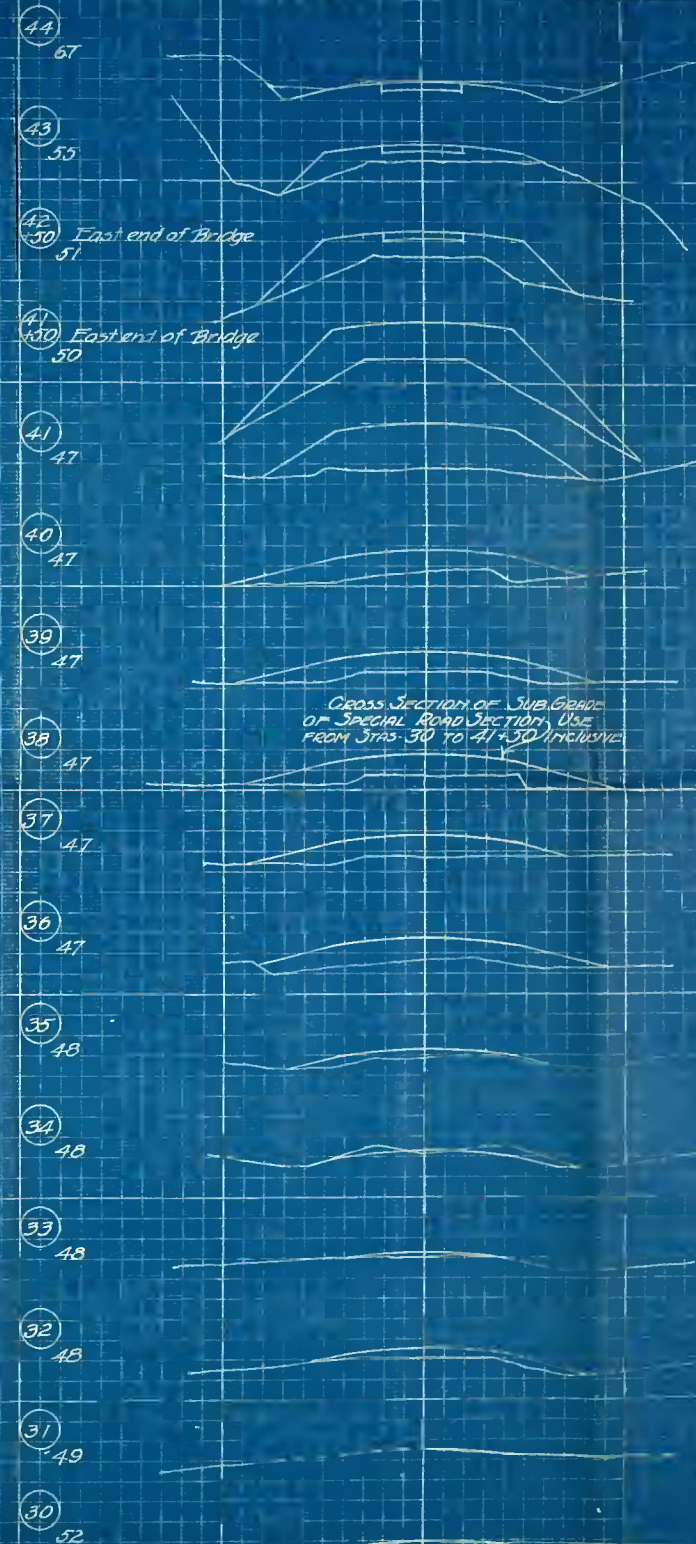
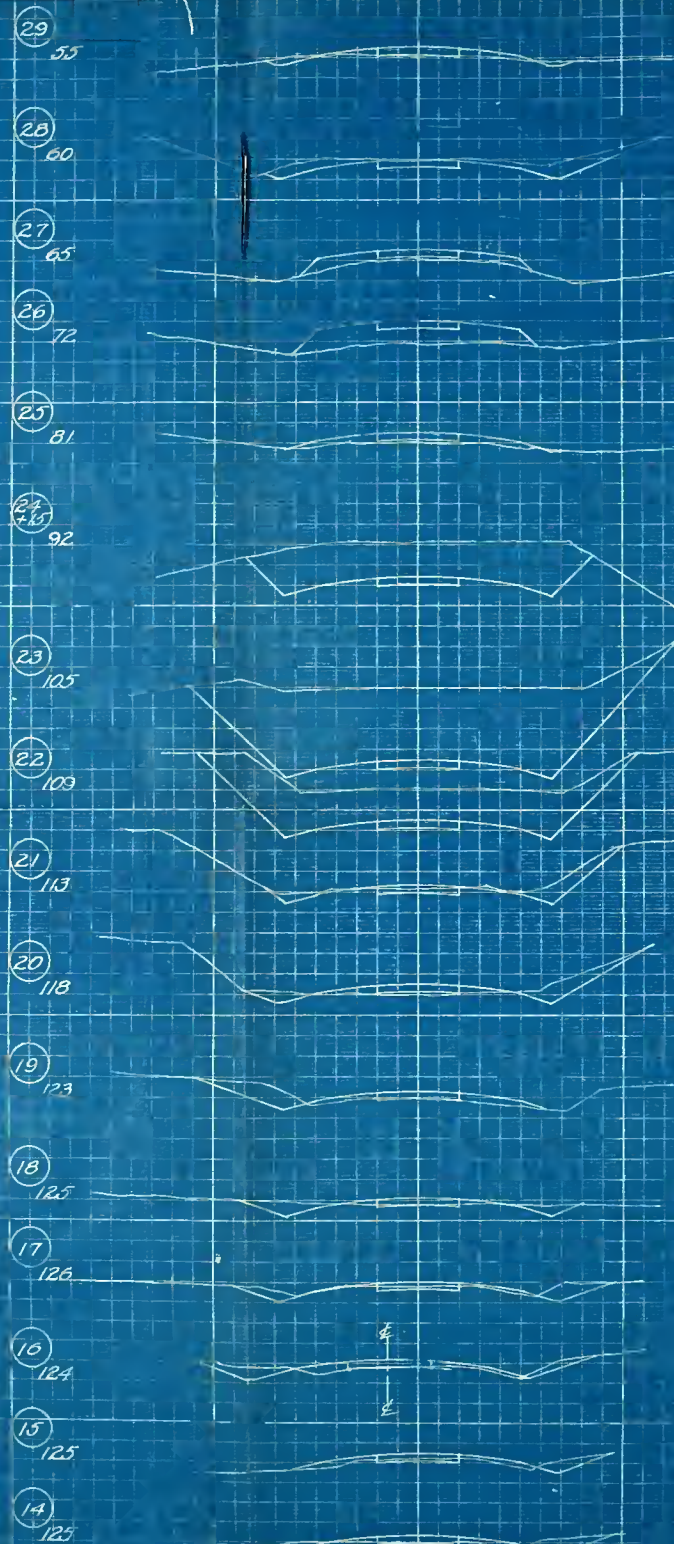
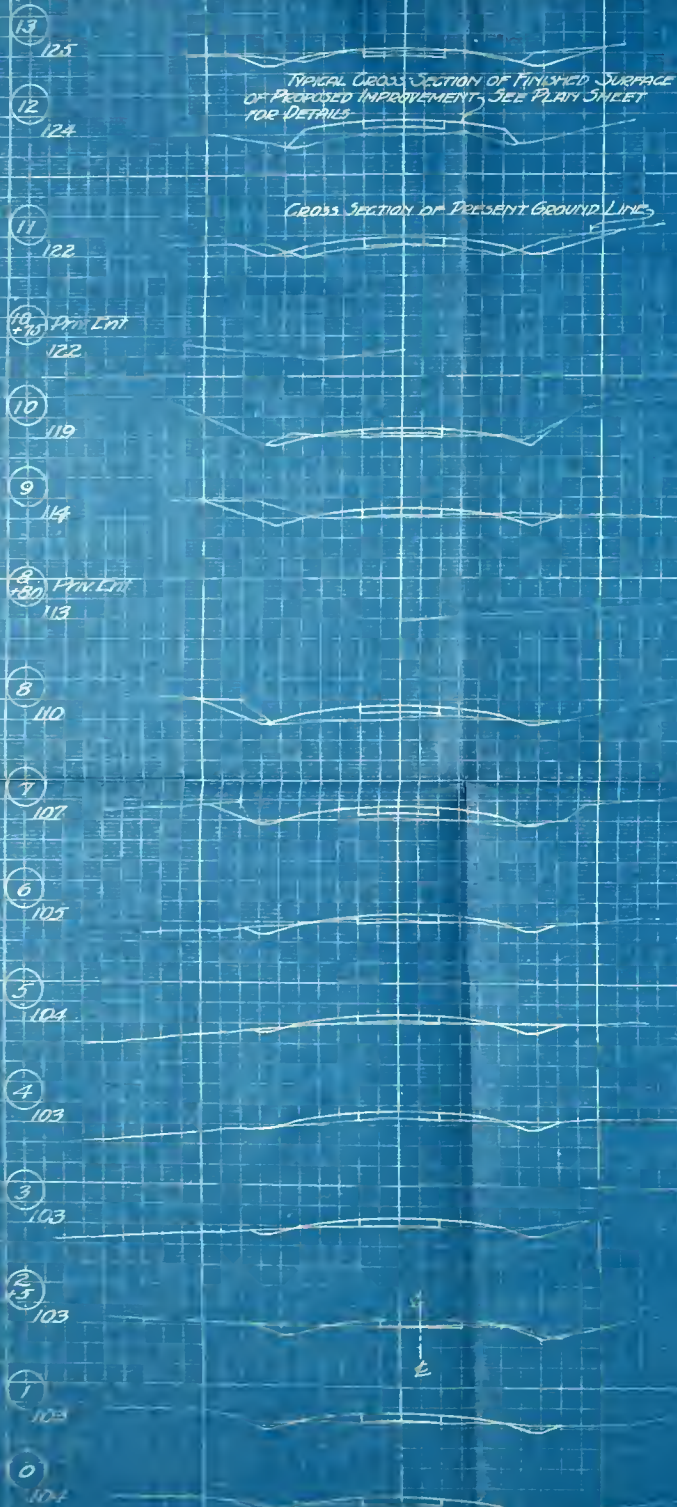
P.T. 125.0

P.T. 125.0

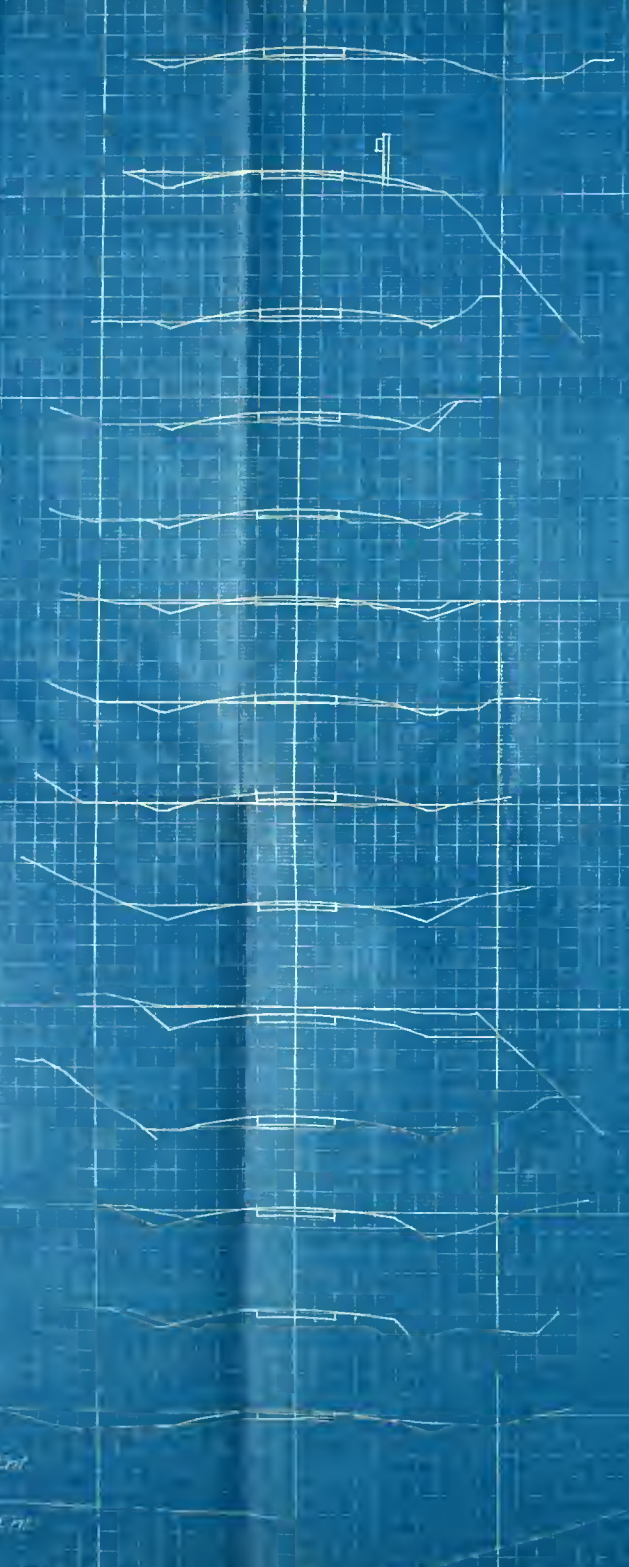
P.T. 125.0



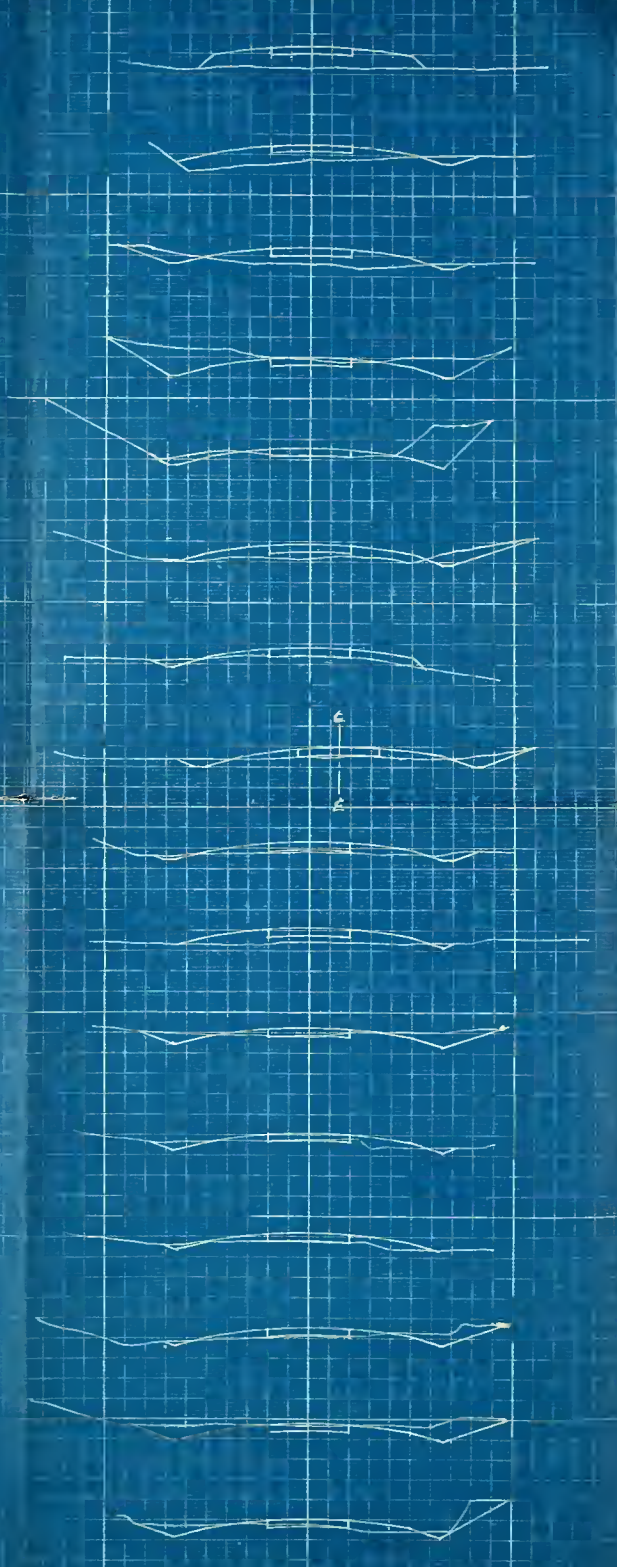




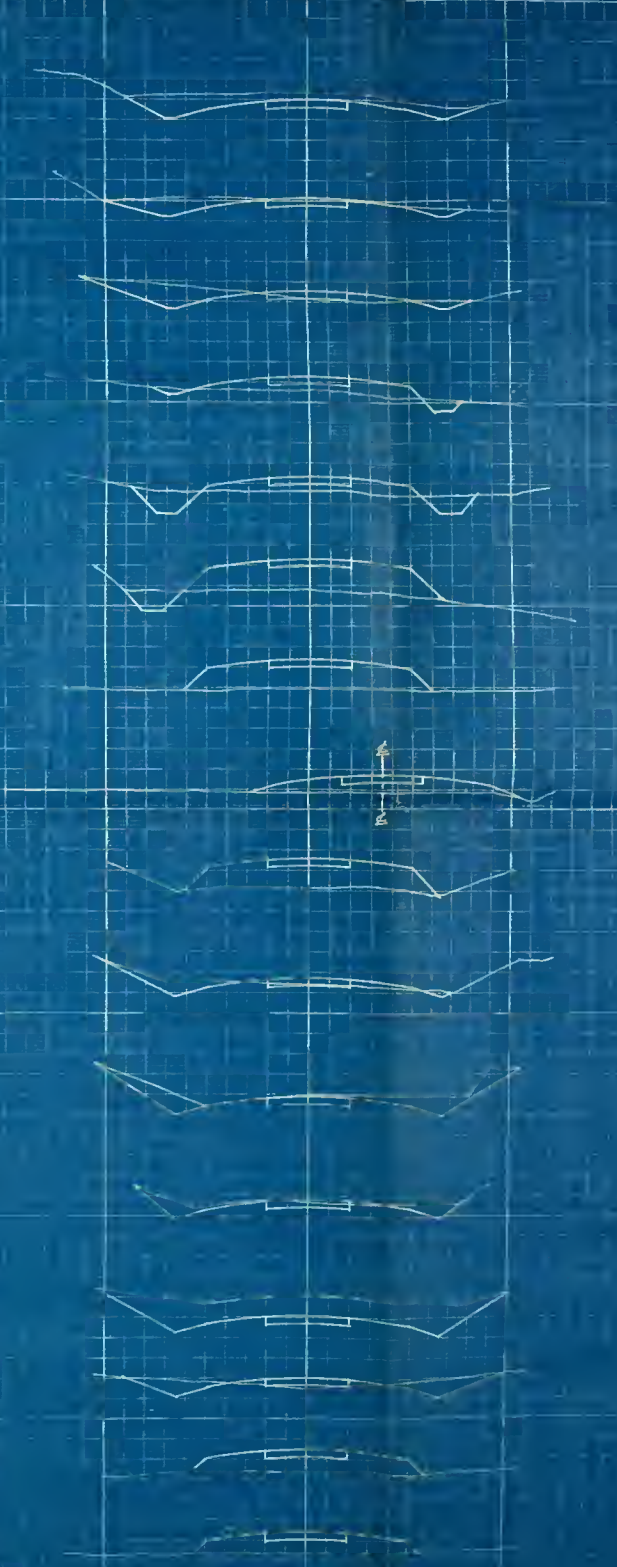
58 98
57 97
56 98
55 100
54 100
53 101
52 109
51 99
50 95
49 9
48 91
47 78
46 73
45 77
44 20
44 10

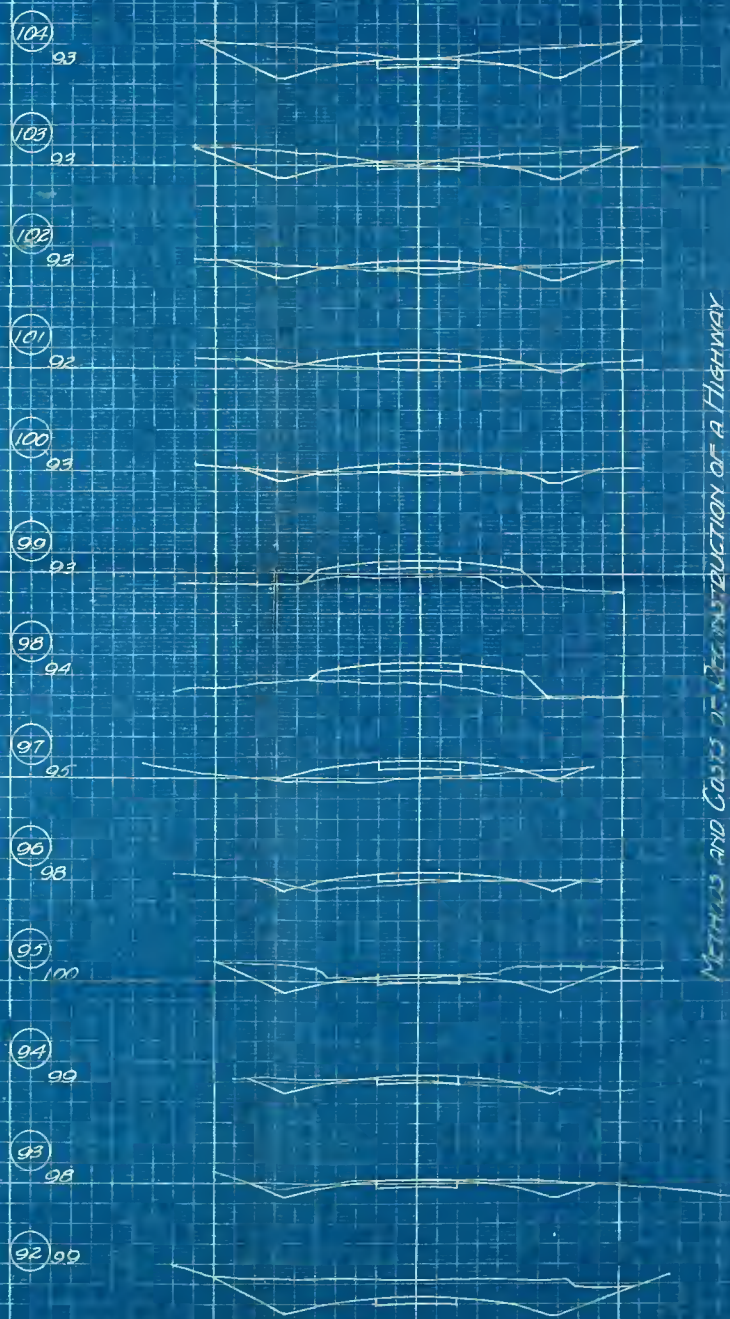
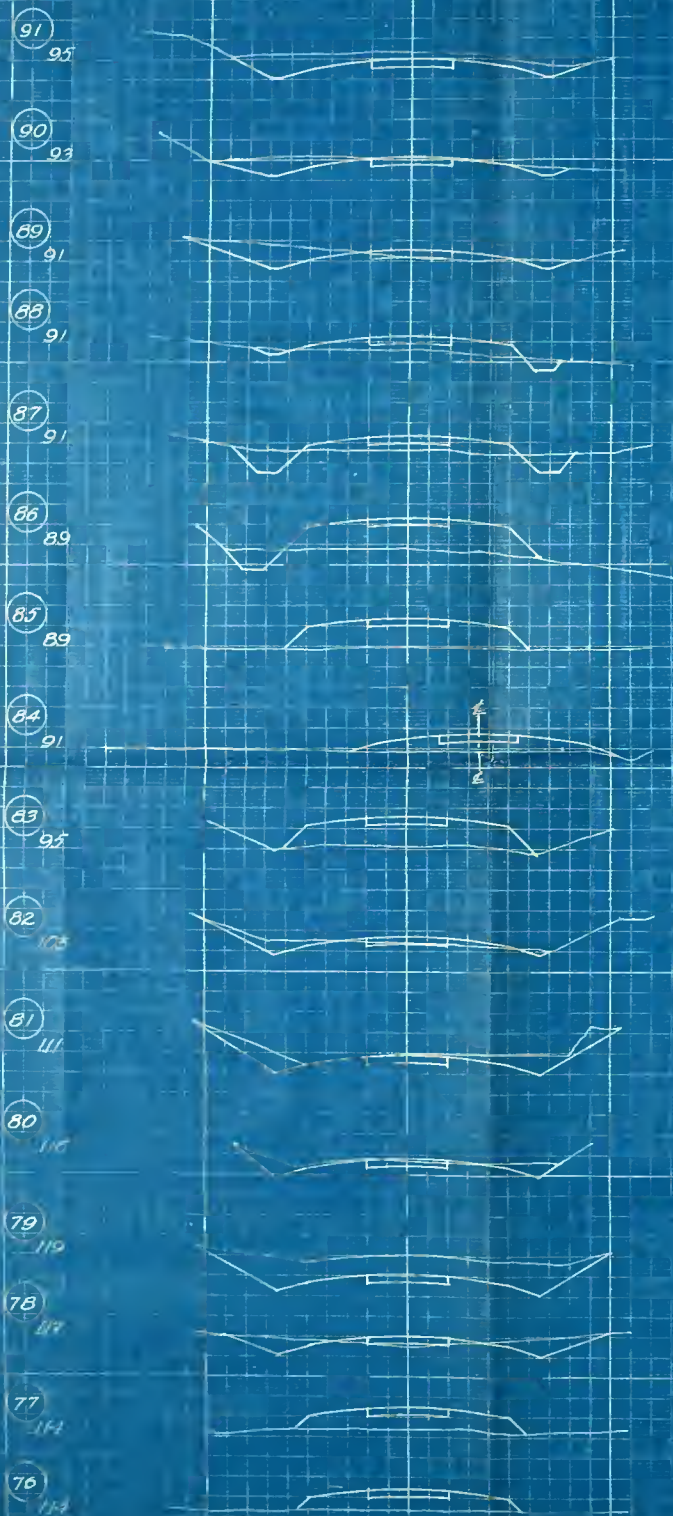


75 114
74 115
73 113
71 108
70 103
69 99
68 97
67 99
66 100
65 100
64 103
63 104
62 102
61 102
60 102
59 100



91 95
90 93
89 91
88 91
87 91
86 89
85 89
84 91
83 95
82 103
81 111
80 116
79 115
78 117
77 114
76 114





METHODS AND CASES OF CONSTRUCTION OF A HIGHWAY

PRESENTED BY

DR. E. H. HARRIS - JAMES D. HENRY - EDWARD F. STADLER

CIVIL ENGINEERING DEPARTMENT
OF
ALBION INSTITUTE OF TECHNOLOGY

MAY 31, 1917

CROSS SECTIONS OF ROAD
SCALE 1/2" = 1'

